(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 576 543 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
31.05.2000 Bulletin 2000/22

(21) Application number: **92908011.7**

(22) Date of filing: **05.03.1992**

(51) Int. Cl.[7]: **A61B 10/00**, A61B 8/08, A61M 25/01

(86) International application number:
PCT/US92/01671

(87) International publication number:
WO 92/16148 (01.10.1992 Gazette 1992/25)

(54) **ULTRASONIC POSITION INDICATING APPARATUS**

VORRICHTUNG ZUR POSITIONSANZEIGE MITTELS ULTRASCHALL

APPAREIL D'INDICATION DE POSITION UTILISANT LES ULTRASONS

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **22.03.1991 US 673949**

(43) Date of publication of application:
05.01.1994 Bulletin 1994/01

(73) Proprietor:
CATHETER TECHNOLOGY, Co.
Princeton, NJ 08540-5706 (US)

(72) Inventors:
- **VILKOMERSON, David**
  Princeton, NJ 08540 (US)
- **LYONS, David**
  Trenton, NJ 08610 (US)

(74) Representative:
Wombwell, Francis et al
Potts, Kerr & Co.
15, Hamilton Square
Birkenhead Merseyside L41 6BR (GB)

(56) References cited:
EP-A- 0 157 302
GB-A- 2 173 593
US-A- 4 236 221
US-A- 4 249 539
US-A- 4 407 294
US-A- 4 508 122
US-A- 4 697 595
US-A- 5 040 225
US-A- 5 076 278

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 576 543 B1

Description

Technical Field of the Invention

[0001] This invention relates to ultrasonic imaging systems for locating the position of an object within a body, for example a medical device, such as a catheter, within a living body.

Background Art

[0002] The accurate placement of catheters and other medical devices has become important in recent years for the treatment of a variety of illnesses, for example, the balloon angioplasty of coronary and peripheral arteries. There are many new uses that will increase the need for precise catheter placement which include stricture dilation performed in the prostrate, selective infusion of drugs to specific sites, and a host of other applications. Catheter placement has been done almost exclusively under x-ray guidance. In such techniques the contrast medium is sent through the catheter while it is being observed by x-ray fluoroscopy, the contrast moving through the catheter and the jet at the tip showing the location. The physician frequently a "interventional radiologist" guides the catheter between x-ray sightings. Limitations on catheter placement by x-rays include the safety issues based on x-ray dosage which were received by the patient and physician and the contrast medium load on the patient's kidneys. Other limitations are related to the need for the procedure to take place in a special room and the need for a radiologist to also be in attendance during the procedure. As one can ascertain both of these requirements add inconvenience and expense to the procedure. Ultrasonic imaging can provide excellent images of many of the blood vessels and prostatic urethra in which these procedures take place. In addition to visualizing the vessels, the Doppler capability of ultrasonic imaging allows measurements of flows achieved by the catheter, as to whether to augment flow or diminish it. There has not been any reliable method of localizing a catheter's position by ultrasonic imaging. This is because the ultrasonic image of the catheter depends on the angle of the catheter to the ultrasonic beam as the catheter moves in the vessel. Some portion of it may become visible, but which portion and when it becomes visible depends on the exact path of the vessel imaged and the particular location of a isonifying ultrasonic source. For these reasons no one uses ultrasound to try to accurately place a balloon catheter, for example, within a peripheral artery even though the artery and the blockage are visible by ultrasonic imaging. The prior art was cognizant of the use of ultrasound imaging to locate the tip of a needle.

[0003] Reference is made to U.S. Patent 4,249,539 issued on February 10, 1981 to David H. R. Vilkomerson et al and entitled ULTRASOUND NEEDLE TIP LOCALIZATION SYSTEM. This patent describes a means for localizing a needle tip using an ultrasound imaging system. The apparatus consists of a small transducer whose location was to be determined, receiving the transmitted pulse of an ultrasonic imaging system and sending it back to the imaging system to show its location. In particular, the patent described the method whereby the return signal was generated electronically and returned directly to the imaging system rather than acoustically back through the body. More general uses of this technique, for example, locating interventional devices in an artery by means of catheter carried transducers are being contemplated. Such uses require an accurate method of showing the position of the localizing transducer. The technique described had various associated problems. In the method described in the patent, a comparator was employed to measure the received signal compared to a reference level. When the received signal was higher the apparatus would generate a pulse that would, after being delayed a time equal to that used in propagating from the ultrasound system to the transducer (i.e., simulating the time required of a pulse reflected by the localizing transducer if direct reflection were used), be inserted into the signal stream of the ultrasonic imaging system, causing a "dot" to appear at the location of the transducer. A problem with that method is that the reference level must be constantly re-adjusted for varying signal levels. When the transmitting transducer is close to the localizing transducer, not only the main lobe but the side lobes of the imaging beam will exceed the reference level, causing a "dot" to appear in several beam positions of the image resulting in a smear in the image.

[0004] If the reference level is reduced to obtain the single beam position that represents the center of the imaging beam and which produces the most accurate location of the localizing transducer, a slight change in the position may reduce the signal level at the localizing transducer enough to eliminate any signal whatsoever, thus erasing the "dot". Thus the prior art required a need for continuous readjustment of the reference level to achieve localization and is a serious drawback to system operation. Also in regard to this particular technique, see an article entitled ULTRASONICALLY MARKED CATHETER - A METHOD FOR POSITIVE ECHOGRAPHIC CATHETER POSITION IDENTIFICATION by B. Breyer, et al and published in The Medical and Biological Engineering and Computing Journal, May 1984, Pages 268-271. As one will understand from that article, the system described has the above-noted disadvantages.

[0005] It is therefore an object of the present invention to provide apparatus to be employed with an ultrasound system which eliminates the need for readjustment of any kind while achieving the optimum localization of the receiving transducer position.

[0006] A further object of the present invention is to provide an accurate and improved system for determining the position of an ultrasonic transducer.

Disclosure of the Invention

[0007] The present invention is directed to an apparatus as defined in claim 1.

Brief Description of the Drawings

[0008]

FIG. 1 is a block diagram showing an ultrasonic imaging system incorporating processing circuitry according to this invention.
FIG. 2 is a detailed block diagram of an ultrasonic position indicating apparatus according to one embodiment of this invention.
FIG. 3 is a detailed block diagram of an ultrasonic position indicating apparatus according to another embodiment of this invention.
FIG. 4 is a flow chart useful in describing a mode of operation of another aspect of this invention.
FIG. 5 is a detailed block diagram of an alternate approach for locating a transducer according to this invention.
FIG. 6 is a timing waveform diagram showing fire pulses employed in this invention.
FIG. 7 is a format depicting the layout of the memory array useful in this invention.
FIGS. 8A and 8B are diagrams depicting the operation of a transducer having ultrasonic waves impinging thereon.
FIG. 9 is a flow chart depicting the sequence of operation performed by this system.
FIG. 10 is another flow chart useful in describing the fire interrupt mode implemented by this system.
FIG. 11 is a flow chart useful in describing a frame interrupt mode.
FIG. 12 is a flow chart useful in describing the operation of the frame interrupt mode.

Best Mode for Carrying out the Invention

[0009] Referring to FIG. 1 there is shown a simple block diagram of an ultrasonic imaging system employing the present invention. The ultrasonic imaging system includes a display 21, which enables the practitioner or user of the system to visualize the portion of a patient's body that is being scanned. Ultrasonic imaging systems have been widely used in medical applications because such systems enable imaging of internal structures of the body without the use of harmful forms of radiation. As seen, the ultrasonic imaging system 20 is associated with a scanning head 10. The scanning head 10 is a hand held unit which the physician manually moves about the body of a patient to thereby perform imaging according to a particular ailment or complaint. As is known in the prior art, it is desirable for hand held scanners as 10 utilizing ultrasound to provide a clear scan picture of the volume of tissue under investigation. The scan picture or display as indicated previously is presented on a display 21. As shown in FIG. 1 the hand held scanner 10 provides a beam of ultrasonic waves 14 which beam is directed into the body 15 of a typical patient under investigation. As indicated, it is a desire to utilize ultrasound to trace the progress of a catheter which may be inserted into an artery, vein, or other body part of a patient under investigation. Such catheters are widely employed. As seen in the figure, a catheter 12 is inserted into an artery 11 of a patient and is moved by a practitioner. As seen, the display 21 depicts the artery as well as the catheter in a conventional manner. In order to locate the catheter so that the physician in viewing the display 21 is able to determine the progress of the catheter, there is shown a transducer 13 which is secured to the catheter and is capable of providing an electrical signal when the surface of the transducer is impinged upon by ultrasonic waves. In this manner the electrical signal provided by the transducer 13 is directed via a wire 16 to the input of a receiving processing circuitry module 19. The circuitry module 19 as shown interfaces with the ultrasonic imaging system via input cable 18 and the ultrasonic imaging system interfaces with the receiving processing circuitry via a cable 17. It is further indicated that the coupling can be done by many different techniques such as electromagnetic or electrostatic coupling. In this manner one can actually couple to, for example, the leads emanating from the scan head 10 to the ultrasonic imaging system without actually making a direct connection to the lead but can do so by means of electromagnetic couplers, and so on. Coupling can also be acoustic by transponding via transducer 13. As will be further explained, it is an objective of the present invention to enable a physician to accurately perceive the location of the catheter 12 in regard to the front of the catheter on the display. Accordingly the system determines the position of the transducer 13 which is located at a predetermined position on the catheter. In this manner, the receiving processing circuitry 19, as will be explained, provides signals to the ultrasonic imaging system which determine the exact location of the catheter and cause the display to display that location so the physician knows exactly where the catheter is being moved and knows the position of the catheter. The transducer 13, for example, may be the type of transducer described in a co-pending patent application entitled ANNULAR ULTRASONIC TRANSDUCERS EMPLOYING CURVED SURFACES USEFUL IN CATHETER LOCALIZATION filed on October 15, 1990 as Serial No. 597,508, later published as WO-A-9206637, which is part of the prior art as defined in Art. 54(3)EPC and assigned to the assignee herein. Before describing the particular system according to this invention, a brief description of the operation will be given in conjunction with the block diagram of FIG. 1.

[0010] As indicated, the hand held scanner 10 emits ultrasonic waves 14 which essentially impinge

upon the transducer 13 causing the transducer 13 to produce an electrical signal. This signal is transmitted along wire 16 where it is received by the receiving processing circuitry 19. The receiving processing circuitry 19 is capable of determining the exact position of the transducer and therefore the catheter in regard to the image being displayed by the imaging system 20. Thus the receiving processing circuit then produces an electrical signal which is directed to the ultrasonic imaging system causing the location of the transducer 13 to be clearly indicated on the display. This can occur by increasing the intensity of the display at that location or by providing a symbol, or by causing the display to flash on and off or by numerous other techniques including adding a different color to the display to indicate the location of the transducer. In this manner by knowing the location of the transducer with respect to the catheter as, for example, so many inches from the tip of the catheter or in the center of the catheter, the physician immediately knows the location of the catheter by viewing the display. For a general understanding of ultrasonic imaging devices including a particular hand held scanner, reference is made to U.S. Patent 4,508,122 entitled ULTRASONIC SCANNING APPARATUS AND TECHNIQUES issued on April 2, 1985 to B. Gardineer, et al and assigned to Ultramed, Inc. of New Jersey. As will be explained, the present invention provides a presentation of the location of the transducer associated with the catheter that enables the system to evaluate the received signal over the entire image frame so that the most accurate localizing image is retrieved and introduced into the actual display. In this manner there is no need for readjustment of any kind to achieve the optimal localization of the receiving transducer position and none of the problems evidenced by the prior art exist in the system according to the present invention.

[0011] Referring to FIG. 2 there is shown a block diagram of a catheter locating system in accordance with this invention. In FIG. 2 the catheter locating system will operate with an ultrasound system which essentially allows the circuit to interface with the existing scan convener included in such a system. Most ultrasound systems employ scan convening apparatus which essentially enables one to generate a proper display. In ultrasound systems the returning echoes from the transmitted pulse provide one line of an ultrasonic image. That line in the ultrasonic image corresponds to the sequence of interfaces encountered by the sonic pulse as it propagates downwardly into the body of the patient. The term scan convener includes any scan controlled system to enable one to format a video display by controlling the scan of the display from such lines. Hence the term scan controller is a broader concept than scan convener. The line information is typically stored in a scan convener that assembles the information from the sequence of lines produced as the scanning head is moved along the body of the patient. The assembled image or frame is in a video format so that it can be displayed directly on a T.V. monitor or recorded on a video recorder, and so on. In such systems the length of the image line or how far down the instrument collects the echo information is set by how long the system receives echo returns. Thus the scan convener must accurately assemble the lines into an image. The determining factor in the accuracy and stability of the image is the positioning of the scan lines, and so on. Thus in FIG. 1, the image shown on display 21 consists of a predetermined number of lines whereby the predetermined number of lines constitutes a frame. This frame is typical in video parlance and essentially determines a discrete number of lines which are implemented by the scan convener. Essentially the start of the frame is the start of the image and is, for example, determined by the scan convener by means of a signal called "Image Start". This is a conventional signal and is shown in FIG. 2 as such. The "Image Start" signal as indicated is produced by all ultrasound systems employing scan conveners and basically determines the start of the image. In a similar manner, the end of the image or the end of the frame is also determined by a pulse which, for example, can be the same exact image start pulse, as the start of a new frame is indicative of the end of the old frame. Between the "Image Start" pulses or frame pulses there are what is known in the art as FIRE pulses. Each FIRE pulse is a pulse which is being transmitted by the scanning head 10 and as indicated is indicative of one line of video information. Thus between each "Image Start" or frame pulse there are a plurality of FIRE pulses which determine, for example, the total number of lines which comprise the picture 21. As one can immediately ascertain, in order to determine the location of the transducer 13, one would therefore have to know the line that the transducer appears at in the video picture as well as the location of the transducer on that line as to whether it is in the center or towards the right or towards the left. Thus as indicated in the video art, one would have to know the coordinates of the transducer 13, at the X-Y address defining the location of the catheter or the X and Y addresses in the video display to define that location. Thus the position of the catheter on a line or on a ray (each pulse indicates a transmitted ray from the ultrasound system) and the exact position on that line or ray (pixel) is generated by this system to determine the location of the catheter in regard to the displayed image. Thus the circuit of FIG. 2 operates to do so, as will be explained. Referring to FIG. 2, reference numeral 30 depicts the transducer as, for example, 13 of FIG. 1 which as indicated when impinged upon by an ultrasound signal emanating from the scanning head will produce an electrical signal. Thus the electrical signal from the transducer 30 is coupled to the input of an amplifier 31. The output of the amplifier 31 is coupled to the input of an analog to digital (A/D) convener 32. The analog to digital convener 32 is of conventional design and may, for example, be an 8 bit or 16 bit analog to digital converter. The A/D convener

32 has one output coupled to the input of an amplitude latch circuit 33. The purpose of the amplitude latch circuit as will be explained is to store the largest amplitude emanating from the analog to digital convener 32 during a frame. The output of the A/D convener 32 is also directed to the P inputs of comparators 34 and 35. Each comparator 34 and 35 is a conventional digital comparator which can operate to compare a signal at the P input with a signal at the Q input and provide an output when the signal at the P input exceeds or is equal to the signal at the Q input. The operation of such comparators is well known. The output from the analog to digital converter 32 which is a digital output is applied to the P inputs of comparator 34 and comparator 35. The Q input of comparator 34 is derived from a noise level number which essentially is a digital number indicative of a predetermined threshold above which the system will operate. In order to compensate for noise which is produced in any such ultrasonic system there must be a certain threshold level that has to be exceeded before the system will operate. Thus the noise level number is a digital number which may be experimentally or empirically selected and applied to the Q input of comparator 34. Hence when the output signal from the analog to digital convener 32 at input terminal P exceeds the noise level number at input terminal Q, the comparator 34 produces an output which is directed to one input of NOR gate 36. NOR gate 36 enables the amplitude latch 33 which amplitude latch 33 will then store the output signal from the analog to digital convener 32. The P input of the comparator 35 is also coupled to the output of the analog to digital converter 32. The Q input of the comparator 35 is coupled to the output of the amplitude latch 33. In this manner the comparator 35 will operate when the signal from the A/D convener 32 is greater than the signal stored in the amplitude latch 33. The amplitude latch 33 always has stored therein the level of the signal which exceeds the previously stored signal and also which exceeds the noise level number. It is further seen that the gate 36 is enabled during the FIRE pulse. Thus during the FIRE pulse a clock oscillator 40 enables gate 36 to thereby assure that if either of the comparators 34 or 35 operate, that the amplitude latch will store the output from the analog to digital convener 32 in proper digital form. The output of the amplitude latch as indicated and shown also goes to a digital to analog convener 39 which converts the digital signal into an analog signal, which analog signal is used to control the gain of amplifier 31, amplifier gain control "AGC". The digital to analog converter 39 is latched at the "Image Start" to change the AGC signal, if necessary, each frame. Thus AGC is updated once per frame. Thus the gain of amplifier 31 is controlled as a function of the signal stored in the amplitude latch 33. When NOR gate 36 is operated, this provides the dot enable signal. The dot enable signal essentially is the signal which indicates to the system that the location of the transducer has been found. The dot enable signal now activates the dot found latch or flip-flop 37. The dot found latch is a normal DQ flip-flop which is always cleared at the "Image Start" pulse. It is of course understood that the amplitude latch is also reset at the "Image Start" pulse. Thus when the dot enable signal is provided the flip-flop 37 activates the dot valid latch 38 which again is another DQ flip-flop. As one can ascertain at the presence of the "Image Start" pulse, the dot valid output of flip-flop 38 will produce a high level indicating that a dot has been found during the last frame. The dot valid signal indicates that a symbol should appear in the image. The location of the dot is determined by circuitry which will be now described. The clock oscillator 40 as indicated can provide a single enable pulse during the firing condition but can also operate to control the analog to digital and digital to analog converters 32 and 39 as well as provide a clock for the up-down counters 41 and 51. As seen, up-down counter 41 is cleared at the "Image Start" pulse which means a clear at the beginning of the frame start. The input to up-counter 41 is the FIRE pulse. The FIRE pulse as indicated above occurs when the ultrasound system emits a pulse indicative of a single line of information. Thus the up-counter 41 counts this pulse. As seen during the generation of the dot enable signal via gate 36 the ray latch or line latch 42 is enabled. In this manner when the dot enable signal is provided, the contents of the up-counter 41 are stored in latch 42. This essentially determines the line in which the dot enable signal appeared. It is of course understood that as the amplitude varies or increases, the contents of the ray latch 42 will also change to always store the line associated with the dot enable signal. The output from the ray latch 42 is directed to latch 43 which is a ray transfer latch. The latch 43 is enabled by the "Image Start" signal. Hence at the end of a frame or the beginning of the next "Image Start" signal, the contents from the ray latch 42 are transferred and stored in the ray transfer latch 43. The output of the ray transfer latch 43 is coupled to the input of buffer 44 which essentially outputs the contents of the ray transfer latch 43 when commanded to do so by the Read Ray Number command present on the enable line of module 43. This Read Ray Number command is conventionally supplied by the scan convener of the ultrasonic imaging system being controlled. Thus the Ray Number Out appears on line 46 and is directed to the scan converter of the ultrasonic imaging system notifying the scan convener that the largest signal during the last frame appeared on a given line. The line has been defined and now the system must know where on the line the largest signal appeared. This coordinate is provided by means of up-counter 51. Up-counter 51 is cleared during each FIRE pulse and has its input coupled to the output of the clock circuit. Thus in this manner each line is broken up into a series of segments determined by the clock input to the up-counter 51. Thus during each FIRE pulse up-counter 51 counts during the length of the line. For example, a

typical line may be broken up into many segments. During the dot enable the pixel latch 52 is enabled by means of the dot enable signal and hence the pixel latch stores the contents of the up-counter 51 during dot enable. The pixel transfer latch 53 operates in a similar manner to the ray transfer latch and is enabled by the "Image Start" signal whereby at the end of a frame, the contents from the pixel latch 52 are transferred to the pixel transfer latch 53. The buffer 54 outputs the pixel number to the scan converter of the ultrasonic imaging system when receiving the Read Pixel Number command. Hence in this manner the scan convener now receives the ray number out and the pixel number and therefore can now modulate that location by means of an increase in the intensity or by color or by pulsing the display on and off. In this manner one accurately determines the largest signal produced by the transducer 30 during the frame and marks that signal on the image for exactly locating the position of the catheter. It is of course understood that the largest signal may be indicative of the center position of the transducer 13. One knows the exact dimensions of the transducer 13 in regard to the overall display and hence one by using the ray number out and the pixel number out information can accurately provide a display of the transducer over more than one line or over more than one ray in the display to thereby give the practitioner an absolute clear view of the exact dimension of the transducer and the catheter with respect to the displayed image. It is, of course, understood that while the above-described system would produce the maximum output or the position of the maximum amplitude signal for a line and pixel it is of course understood that by a simple modification of the system shown in FIG. 2, one could provide a plurality of signals all of which are associated with large amplitude and then from such signals make a more accurate determination of the exact location of the catheter. For example, as one will ascertain the transducer 13 is essentially physically wider than one line of the image and may, for example, appear in four or five lines. The four or five lines all of which will have a large amplitude associated therewith, will also be approximately located at about the same pixel in consecutive lines. For example, the catheter may be as wide as lines 100, 101, 102, and 103 and being approximately at the same pixel or at close pixels during each line. Therefore, one would expect large signals during pixels for each of those lines. Thus it would become immediately apparent to one that the system can be accommodated to operate in this manner and store the four largest signals or a given number of large signals in consecutive lines at about the same pixel locations. When one indicates at about the same pixel location, one is essentially saying that the transducer may not be perfectly vertically oriented and may, in fact, be at a positive or negative slope with respect to the vertical or horizontal axis and therefore the pixel location associated with each of the lines may vary. As indicated above, the block diagram associated with FIG. 2 is pertinent when one has direct access to the scan converter of the ultrasonic imaging system. The reason for this is that the scan converter when receiving a ray and pixel number would know exactly where to insert the image of the catheter on the display. As explained above, the amplified signal from the localization transducer 30 is compared to the highest value previously experienced during the frame. The above discussion shows a digital implementation of the circuitry but as one can understand everything described above can be done in analog fashion as well, utilizing for example capacitor storage devices, and so on and hence one can operate directly with analog signals. It is, of course, understood that the digital implementation is more reliable in regard to noise and other variations. As indicated above, when a large amplitude is detected its position in both acoustic beam position representing the angle from the transmitting transducer and in time of occurrence representing the distance from the transmitting transducer is stored. Thus, at the end of the frame where one has completed the scan of the area of interest, the exact position of the highest signal is stored in the registers 43 and 53. The signal must be higher than the noise level for the system to be enabled. As indicated above, this information determines precisely the location of the dot in the image that represents the localizing transducer's position. In FIG. 2 the information is used to add the dot into the image by directly connecting to the scan convener whereby the beam number and time are translated to the proper position in the image. This localizing dot as displayed in the image can be shown in color by means of what is known as graphic overlay on the image. There can be multiple transducers which can be located and they can be coded differently, as one can ascertain.

[0012] Referring to FIG. 3 there is shown a technique which can be employed on ultrasonic imaging systems which do not have easy access to the scan converter. In the embodiment shown in FIG. 3 after the proper position is calculated, the dot is entered into the next frame. Thus the stored ray number where the signal was the highest is compared to the present ray number. When they are equal, a pulse is introduced into that transmitting transducer line at a time equal to twice the time measured between the transmit pulse and the maximum signal occurrence. The doubling in time compensates for the propagation time back from the localizing transducer to the transmitting transducer. Thus a bright dot is shown at the precise location of the localizing transducer. This doubling in time would not be required if transducer transponding is implemented as by pulsing the transducer. It is, of course, understood that the transducer 60 can be located on any medical device. As shown in FIG. 3 the catheter transducer 60 again is coupled to the input of the amplifier 61 whose output is supplied to A/D converter 62. The A/D converter 62 supplies inputs to the P input of comparator 64 and 65. Comparator 64 provides an output when the

signal exceeds the noise level number input to comparator 64 which amplitude is stored in the amplitude latch 63. The comparator 65 again produces an output when the input signal from A/D convener 62 exceeds the amplitude value stored in latch 63. The digital to analog convener 67 controls the gain of amplifier 61. As noted, the digital to analog convener 67 is latched at "Image Start". Thus the AGC signal is updated once per frame. The output of NOR gate 66 again produces the enable signal which as indicated above operates the dot found latch at the "Image Start" or at the beginning or end of frame signal via the latch 68. The output of latch 68 is coupled to latch 69 which is the dot transfer latch. The display dot signal is now applied to the input of NOR gate 79 instead of to the scan converter. This will be further explained. In any event as indicated, the clock is applied to the analog to digital converter 62 and to the NOR gate 66 as well as to the up-counter 72 as previously indicated. However, the clock is also applied to a divide by two 82 which is cleared during the presence of each FIRE signal. This clock 82 is supplied to the Data In Down-counter 78 which will be described further to explain how the dot is provided in the system of FIG. 3. Similarly as described above, there is an up-counter 71 which up-counter 71 produces a count for each FIRE pulse occurring during the frame. The up-counter 71 is cleared by the "Image Start" signal. Thus the up-counter 71 counts each line in the image display. In a similar manner, the up-counter 72 is operated to provide a pixel count and is cleared upon each FIRE pulse and begins to count up, giving a predetermined number of pixels for each line or ray. Thus as seen, the pixel up-counter 72 operates in conjunction with the pixel latch 76 which is enabled by dot enable as well as the pixel transfer latch 77 which is enabled by the "Image Start" signal. The pixel information is applied to the data input of the down-counter 78. The output from up-counter 71 which has the line value stored therein is applied to one input of a ray comparator 75. The other input from the ray comparator 75 is applied from the ray transfer latch 74. In this manner the ray comparator 75 compares the present line number with the stored line number. Thus with the "Image Start" the ray latch value and the pixel latch value are transferred to the ray transfer latch 74 and the pixel transfer latch 77. Also the dot found latch value is transferred to the dot transfer latch 69 to generate the display dot signal. In the next image frame the ray comparator signals from comparator 75 provide a signal when the current image ray number is the same as the ray number stored in the ray transfer latch 74, which latches, at each "Image Start", the contents of ray latch 73. When this occurs, the value in the pixel transfer latch is loaded into the down-counter 78. The down-counter 78 is then decremented to zero with the clock 82 at one-half the frequency of that used to acquire the catheter location. This performs the necessary time doubling as described above. When the down-counter 78 reaches zero and produces the carry the resulting dot signal is amplified and level shifted via module 90. The output of module 90 which is the amplifier level shift is applied to the input of a summing amplifier 83. The summing amplifier receives at its input the imaging video input which is obtained from the ultrasonic imaging system. Thus the dot video information is summed with the imaging video information to produce an imaging video output signal on line 84. This imaging video output signal contains the dot location indicating the location of the catheter and is applied to the video signal of the display to thereby add the catheter location to that video signal. Also shown coupled to the input of NOR gate 79 is the output of AND gate 81 which receives a blink enable signal at one input and has at the other input an "Image Start" signal divided by 2 by means of divider 80. In this manner the gate 81 when enabled will enable the dot location to blink or to be provided every other frame which would provide a blinking action.

[0013] Referring to FIG. 4 there is shown a flow diagram which can be implemented by hardware or via a microprocessor which further addresses the problem of adding the catheter location to an image display. As one will understand, ultrasonic imaging systems of the prior art utilize scan converters which may produce 4-20 frames a second. The catheter, for example, may be moved very rapidly or very slowly. If a catheter is moved slowly, then the transducer will be about the same position during a number of consecutive frames and as one will understand a dot is produced for each frame. Thus the number of dots produced is a function of the speed of movement. If the catheter is moved rapidly, then the dots will produce a line on the display instead of a pinpoint location of the catheter, as one will understand. In FIG. 4 there is shown a simple flow chart which can be implemented as indicated by conventional hardware or by a microprocessor as can, for example, the entire hardware shown in FIG. 2 and FIG. 3. In order to prevent a line representation or a smear on the display, the logic shown in FIG. 4 is used. As indicated, module 90 reads and stores the present ray and pixel number. The present ray and pixel number are compared with the previous ray and the previous pixel as indicated in module 91. If they are not the same, then as evidenced by module 96 the old dot location is erased or removed and a new dot is placed at the new pixel and ray location as indicated by module 96. If they are the same, then module 92 indicates as whether to provide a blinking of this location. If a blinking is not to be provided, then one leaves the program. If the blinking is to be provided then module 93 determines whether there is a dot on the screen. If there is a dot on the screen, the dot is erased as indicated by module 94. If there is not a dot on the screen, a dot is placed on the screen as indicated by module 95. In this manner one can now blink the dot every other frame as indicated by the flow chart. In a practical manner the flow chart indicated in FIG. 4 can be very simply implemented due to the fact that the value of each ray and each pixel during the generation

of a dot are known plus the fact that the previous values of the ray and pixels are also stored by means of the latches. It should therefore be apparent to one skilled in the art that the above described techniques are extremely reliable in the fact that the system utilizes an entire image frame to determine the optimum signal during that frame and therefore provide the most accurate location information concerning the catheter in conjunction with the transducer coupled thereto. It is also apparent that many variations of the above can be utilized as, for example, more than one amplitude signal can be stored and compared to determine whether the transducer has appeared in consecutive lines which is normal procedure due to the finite size of the transducer. In this manner one can actually trace out the exact location of the transducer and therefore the catheter location during a display and on a frame-to-frame basis.

[0014] Referring to FIG. 5 there is shown an ultrasonic position indicating apparatus which employs a microprocessor 101. As will be explained, the microprocessor 101 controls the operation of the circuitry to be described. The circuitry enables response to signals which occur during each of the scan lines and to locate a number of consecutive signals above a predetermined amplitude within a frame. By determining these consecutive signals one locates the position of the transducer in regard to the display. This enables one to show the transducer on the display by various means, such as a bright dot, an arrow, or any other way of highlighting the transducer with respect to the ultrasonic image display.

[0015] As one can see from FIG. 5, the microprocessor 101 receives the FRAME signal and the FIRE signal at the real time inputs. The microprocessor has a data bus 105 which, as will be explained, operates to interface with the above-noted circuitry. The microprocessor also has real time outputs designated generally by reference numeral 106 which enables control of the above-described circuitry. There is a 20 Mhz oscillator 102 which operates as a system clock. The output of the oscillator 102 is directed to the clock input of the microprocessor 101. The output of the oscillator 102 is also divided by two via a divider module 103 which output serves as the clock input to various other modules included in the system. Also shown in FIG. 5 is the transducer 100 which is positioned on a catheter which is directed into the body of a patient. It is of course understood that the transducer 100 can be located on any medical device. The transducer 100 is of the type which will emit or return a signal when ultrasonic waves impinge upon the surface of the transducer. The transducer provides this signal electrically as being a piezoelectric device or by other means. The output from the transducer is applied to the input of an amplifier 110 which amplifier is capable of having its gain controlled via the AGC input. The output of the amplifier is again applied to an analog-to-digital convener 111. The operation of the analog-to-digital convener 111 is to convert the analog signals received from the transducer 100 at the input to digital signals at the output. The output from the analog-to-digital convener is directed to a latch 195. The function of the latch 195 is to store in real time each digital output or each 8 bit output of the analog-to-digital convener 111. The output of the latch 195 is directed to a comparator 116 and also to a second latch 118. The function of the second latch 118 is to store any signal which is larger than the previous signal from the analog-to-digital convener 111. Essentially the comparator 116 operates as the comparators described above. The comparator 116 takes the output from latch 115 and compares the output of latch 115 with the last largest signal stored in latch 118. If the signal from latch 115 is larger than the signal stored in latch 118, then the comparator causes the new larger signal to be stored in latch 118 for further comparison. The output of latch 118 is transferred to latch 117 under control of the microprocessor 101. In this manner latch 117 always has the largest signal stored therein. The output of latch 117 is directed to one input of a select output module 120. Module 120 as will be explained, essentially is a switch which is under the control of gate 121. The inputs to the gate 121 are obtained from the microprocessor outputs 106 which enables the select output switch to either select the largest amplitude signal as stored in latch 117 or to select the pixel signal which is stored in latch 131 as will be explained. The output of the select output module 120 is directed to an amplifier 122 which amplifier is coupled directly to the data bus 105 of the microprocessor.

[0016] Thus from the above, it is seen that the amplitude of the largest signal for each FIRE signal or ray which emanates from the transducer 100 is stored in latch 117. As indicated, a fire pulse is divided into a number of line segments to enable the pulse which is of largest magnitude to be defined in terms of an XY coordinate. In this manner when a large amplitude pulse appears and is stored in latch 115 one desires to know the fire pulse at which this pulse appeared as well as the position of the pulse between fire pulses. In this manner as explained above, the XY location of each pulse can be ascertained. In order to do this, the system includes an up-counter 132. The up-counter 132 receives the clock from the output of the frequency divider 103. Essentially the up-counter 132 is cleared during each fire pulse. As seen in FIG. 5 the fire pulse is also coupled to a masked fire circuit 133 which essentially is a one-shot. The masked fire circuit 133 resets the up-counter 132 at each fire pulse. The up-counter 132 begins to count up at the rate of one-half the clock frequency. In this manner each fire pulse is divided into a series of smaller intervals or segments by means of the up-counter. Each time the comparator 116 indicates that it has received a larger signal from the analog-to-digital converter, the pix latch 131 is also enabled. When the pix latch 131 is enabled the pixel or line segment at which the larger pulse appeared is automati-

cally stored in latch 131. The output of latch 131 is directed to the other switching input of the select output module 120. In this manner the select output module 120 can either direct the pixel or the maximum amplitude to the output amplifier 122. There is also shown a down-counter 134 which also is clocked by means of the output of the divider 133. The down-counter is loaded by the microprocessor basically from the D bus 105 and receives the load signal from the microprocessor at the output designated as 03 (PIX). The function of the down-counter 134 is as follows. When the microprocessor receives the largest amplitude signal during the fire pulse, it also receives the pixel number. In order to display the signal on the imaging system display, one must realize that when the ultrasonic wave hits the transducer surface 100 it is now being reflected back to the scanning head of the ultrasonic system. In this manner the propagation time is twice the time for the ultrasonic system. What is meant is that the transducer produces a pulse when the ray strikes the surface of the transducer. However, this pulse is reflected back through relatively the same path. Hence the time for the pulse to arrive at the ultrasonic system or the ultrasonic scanning head is twice the time it takes for the pulse to arrive at the transducer surface. In this manner the microprocessor loads the down-counter with twice the pixel number associated with that ray so that the down-counter 134 when it reaches the count of zero will be at the fight place in regard to the picture format. The output of the down-counter is directed to gate 138 which is an AND gate. The other input to AND gate 138 is derived from the level changer 135 which is also controlled by the microprocessor 106. In this manner the microprocessor 106 activates the level changer 135 at suitable intervals and when the down-counter reaches zero, a dot is produced at the proper XY location on the display. This dot or pulse serves to highlight the display at the XY coordinate of the location of the transducer. The output of the dot gate 138 goes through a cable pulser 139 which, as indicated, can inject the pulse directly into the scanning head by means of electromagnetic coupling. The dot output can go directly to a summing amplifier 140 which again sums the video signal with the signal obtained from the ultrasonic imaging system and with the output of the summer directed to the scan convener as previously explained in regard to the circuit shown in FIG. 3. Thus one can ascertain briefly above how the circuitry works. In FIG. 5 there is also shown a digital-to-analog latch 136. The latch 136 has an input coupled to the bus 105 which comes from the microprocessor and has an output coupled to a digital-to-analog converter 137. The output of the digital-to-analog converter 137 is designated as AGC. As will be explained, the microprocessor provides a digital code which is converted to an analog signal to provide the AGC signal for amplifier 110. In this manner the signal provided by the microprocessor, as will be explained, is coupled to the input of the D/A latch 136 which essentially transfers this signal to the digital-to-analog converter 137. The digital-to-analog converter 137 converts the digital signal into an analog AGC signal which is applied to the AGC input of amplifier 110. In this manner a suitable AGC signal is provided to enable amplifier 110 to efficiently respond to any pulse received from the transducer 100.

[0017] Reference will now be had to FIGS. 6-12. It is noted that in regard to the discussion of these figures, there may be reference back to FIG. 5 to essentially show how the microprocessor 101 operates in conjunction with the remaining system components.

[0018] FIG. 6 shows a series of fire pulses which produces a frame. An ultrasonic system may employ 256 fire pulses to thereby produce a 256 line display or may produce 512 fire pulses to provide a display of 512 lines. The number of fire pulses employed in various ultrasonic systems can vary. Essentially each time a fire pulse is emitted, the ultrasonic system produces an ultrasonic beam of energy also designated as a ray.

[0019] The microprocessor serves to interrogate gate 121 (FIG. 5) to thereby cause the select output 120 to transfer to the microprocessor via amplifier 122 the maximum amplitude received during each fire pulse or ray and the pixel number or the location of that maximum pulse with respect to the ray. This is done by the microprocessor by activating inputs Iϕ and I-2 of gate 121. In this manner as shown in FIG. 7 the microprocessor has stored in a memory array the maximum amplitude and pixel number for each ray as O to N. The microprocessor as seen in FIG. 6 produces the pulses to operate gate 121 at the read time which is shown at a time right before the next fire pulse (dashed line). It is understood that the microprocessor is responsive to the fire pulse based on the FIRE input to the microprocessor. The microprocessor also computes the start and end of a frame, typically by noticing an interim of cessation of fire pulses. The microprocessor thereby monitors each of the fire pulses and controls the circuit accordingly. Thus as shown in FIG. 7, the microprocessor has stored in various memory locations the amplitude of the maximum pulse which occurs during each ray and the pixel or line segment at which the pulse occurs. At the end of a frame which constitutes N rays or N fire pulses as, for example, 256 or 512 or any other number, the microprocessor then adds all the amplitudes stored in the memory array for the given number of rays and divides the sum by the given number of rays. Thus for example, the microprocessor will add all the amplitudes stored in each of the memory locations designated as O to N and then divides the number by N+1. In this way the microprocessor obtains an average amplitude signal value for each frame. The average value for each frame is then subtracted from each amplitude value stored. In this way the microprocessor can suppress noise that may affect the pulses received during a frame. By responding to consecutive pulses of larger amplitudes the microprocessor can select the XY locations of the transducer. This will be explained in greater detail.

[0020] In FIG. 8A there is shown an enlarged view of the transducer 13 with a series of ultrasonic waves impinging on the surface and being reflected. FIG. 8B essentially shows the response of the transducer 13. It is seen, for example, that the amplitude at ray 6 as shown in FIG. 8B is larger with it being less at ray 5 and ray 7 and less at ray 4 and ray 8. In FIG. 7, it is shown that the same sequence of events occurs whereas the amplitude is maximum, namely 38 at ray 6, 33 at ray 5, 34 at ray 7, 35 at ray 8, and 30 at ray 4. Thus instead of searching for the largest magnitude pulse during the frame as previously described, the present system looks at groups of pulses to determine from such information where the transducer is. This further reduces any chance of random noise affecting the system, as random noise would not occur as a sequence of pulses. Furthermore, the system then develops an average voltage based on all the amplitudes stored during a frame to thereby control the threshold of the system according to the value stored. In order to fully understand the operation of FIG. 5 in conjunction with the explanation of the waveforms and storage array discussed in FIGS. 6, 7, and 8, reference is now made to the flow charts starting in FIG. 9.

[0021] Thus referring to FIG. 9 there is shown a flow chart which is useful in explaining the operation of the microprocessor 101 of FIG. 5 and to further show operation of the system. The program starts at module 200 and 201 whereby there is an initialize and enable interrupts by the microprocessor. This enables the microprocessor 101 to be receptive to any information which appears on input lines designated as FRAME and FIRE. The microprocessor then begins to operate according to main program 202. This can be any type of program. The microprocessor 101 can be time shared or could perform operations according to the main program, for example, calculating the average of all values stored in the array as shown in FIG. 7 or compute the time between fire pulses, and so on as will be further explained. Essentially the microprocessor looks for a fire pulse to be received on its input line as shown in FIG. 5. Hence module 203 questions, Has a fire pulse been received? If a fire pulse has not been received then operation continues via the main program. If a fire pulse has been received, then the program questions whether it is time to read the amplitude and pixel number of the maximum transducer signal during the last fire period. This is done in module 204. Referring to FIG. 5, the microprocessor 101 receives the fire pulse and begins to count up from the receipt of the fire pulse as the microprocessor knows when to expect the next fire pulse. This is based on the repetition rate of the system. Therefore the microprocessor will initiate the read signal as shown in FIG. 6 before the next fire pulse is expected. This is a time calculation which is done by the microprocessor whereby the microprocessor at a given time indicates that it is time to read the amplitude and pixel as shown in module 204. The microprocessor then first activates the IϕMAG output which causes gate 121 to select the output from amplitude latch 117 which then is applied via the amplifier 122 to the bus 105 of the microprocessor. Hence during this mode the microprocessor receives the amplitude of the signal. The microprocessor also knows which fire pulse this is as it receives all fire pulses and counts fire pulses. Hence the microprocessor already knows that this is the first fire pulse of the new frame or the second or the third and hence stores the amplitude in the memory array as shown in FIG. 7. The microprocessor then activates the I-2 PIX read which then causes switch 120 to select the pixel number from latch 131 and which again is directed to the output of amplifier 122 to give the microprocessor the pixel number. This is also stored in the memory array adjacent to the amplitude received. Thus as shown in module 205 the microprocessor stores the amplitude and pixel number in the array. After this is done the microprocessor as shown in module 206 clears the A/D converter hardware and disables show dot. This is done to prevent any ambiguities from occurring. The microprocessor then returns to the main program after the clear sequence as shown by module 206. Thus for each FIRE pulse the microprocessor "reads" the amplitude latch 117 and the pix latch 131 via the select output switch 120 and stores the maximum amplitude and pixel location in the memory array for each ray or FIRE pulse. As also seen in FIG. 9, after the initialization and enable interrupts in module 201 the microprocessor also executes a fire interrupt enable program each time a fire pulse appears. The microprocessor via module 207 looks for a fire pulse at the input. If there is a fire pulse the microprocessor enables the fire interrupt program. The microprocessor in module 208 interrogates to determine whether there is a fire pulse. If there is no fire pulse, the microprocessor returns to its initial status. If there is a fire pulse the microprocessor executes the fire interrupt program. In a similar manner as one can see, there is also a frame interrupt enable program as evidenced by module 209. Hence the microprocessor also looks for a frame signal on the other input lead. If there is a frame signal, the microprocessor institutes the frame interrupt program as evidenced by module 210. If there is not a frame signal, the microprocessor waits for another input from module 209.

[0022] Referring to FIG. 10 there is shown the flow chart for the fire interrupt mode as indicated by module 208 of FIG. 9. During the fire interrupt mode the microprocessor then disables the show dot and enables the analog-to-digital hardware as evidenced by module 211. Referring to FIG. 5 the microprocessor disables the show dot gate 138 by means of the level changer latch 135 which is set by the microprocessor during the fire interrupt mode and during the fire pulse the microprocessor also enables latch 117 and clears the largest value latch 118 to allow the new fire pulse to commence operation. The system operates so that it collects data

during all odd frames as 1, 3, 5, 7, and so on and transmits data during all even frames as 2, 4, 6, 8, and so on. This is just a convenient way of operation on a frame-to-frame basis and essentially any other combination of collecting and transmitting data based on various frames and so on can be implemented as well. Hence FIG. 10 shows a module 212 which indicates odd frame. If it is an odd frame, the system will collect data. Thus the output from module 212 designated as YES is directed to module 213 which specifies that the microprocessor enables the A/D convener 111 hardware and disables the show dot. This is redundant as this was done in module 211 but is a further check to assure reliable operation. Thus the same latches as 117 and 118 are set as well as the fact that the level changer and show dot gate 138 are disabled. Then the microprocessor proceeds to compute the previous fire period and to increment the fire count 214. As indicated, the microprocessor knows exactly the fire period which is the period between fire pulses and essentially counts down until it reaches a count indicative of the read location where the microprocessor will read the maximum amplitude and pixel values as described above. In the meantime the microprocessor computes the fire period and starts incrementing the fire count as evidenced by module 214. As shown in module 215 the microprocessor knows if the fire period is too long or too short. Essentially, the microprocessor will determine that it has received a fire pulse which is an improper pulse. If that occurs, then the microprocessor will determine that the fire period is too short or too long if the fire pulse does not appear when anticipated as evidenced by module 215. If either event occurs, the microprocessor is instructed to start over again. As one can see this will not affect circuit operation. If a proper fire pulse is received, the microprocessor calculates the time for the system to then read the amplitude and pixel value via gate 121 as described, and this occurs in module 216. After that is done, the microprocessor is finished with that phase and there is a return from the fire interrupt sequence as determined by module 217. Again referring to FIG. 10, if the frame is not an odd frame and therefore is an even frame as evidenced by module 212, then data is transmitted. As seen via module 218, the microprocessor loads the down-counter 134 of FIG. 5 with the output dot pixel location as explained above. Thus the microprocessor enables down-counter 134 via the output leads. The microprocessor then, as evidenced by module 219, increments the fire count accordingly. As one can understand, the microprocessor receives the dot pixel location and stores it via the array. The microprocessor knows what pixel or the Y location that the maximum amplitude pulse occurred at. The microprocessor also knows the ray or the fire pulse at which this maximum amplitude occurred. Therefore the microprocessor increments the fire counter 219. When the fire count equals the fire dot number which essentially says that the pixel is now at the correct ray or line, the microprocessor then enables the down-counter 134 via the LD input to enable the down-counter to begin counting down during that fire pulse as explained above. The microprocessor will then also enable gate 138. In this manner when the down-counter reaches the count of zero, a pulse is produced at the output of gate 138 to thereby increase the intensity of the display. This clearly indicates the location of the transducer on the display either via the cable pulser 139 or via the summer amplifier 140. After this has been accomplished as shown by module 221 the system then goes into the return from fire interrupt mode 217 back to the main program or back to module 207.

[0023] Referring to FIG. 11 there is shown the frame interrupt sequence as, for example, further depicted in regard to FIG. 9. During the frame interrupt the microprocessor upon receiving a frame interrupt pulse at the input makes a determination as to whether this is an odd frame or an even frame. As indicated above, the data is collected during odd frames and transmitted during even frames but the particular sequence utilized is of no significance. This is done via module 250. If it is an odd frame, the microprocessor sets the odd frame indicator to FALSE as shown in module 253. What this means is that the next frame will be an even frame. After setting the odd frame indicator to FALSE, the microprocessor then produces the signal average as described above. In this manner the microprocessor then adds all of the amplitudes stored in the array for the frame and divides that value by the number of locations in the array to obtain the signal average. The microprocessor then determines via module 255 as to whether or not the signal average is too big or too small. This is done strictly on pre-program thresholds which are programmed into the microprocessor as will be clearly understood. If the signal average is too big or too small, the microprocessor forces an average signal value via module 256 to be used by the circuitry. Thus the microprocessor upon determination that the average signal value for that particular frame was too big or too small will set some sort of average value which is indicative of a noise level. If the signal average is not too big or too small, then the microprocessor indicates this via the no input and continues the frame interrupt processing which will be described in conjunction with FIG. 12.

[0024] Referring to FIG. 12 there is shown the operation of the microprocessor in selecting groups of pulses in order to determine whether a transducer signal has been received. Thus as seen in FIG. 12, the microprocessor after providing the contents of the array as, for example, shown in FIG. 7, now proceeds to scan the array to find groups of five or more consecutive returns or consecutive fires whose pixel numbers are within ten of each other. Essentially what the microprocessor will do is to look at all the pixel values and the amplitudes to determine whether or not there has been sufficient amplitude in consecutive fires at consecutive

rays where the pixel numbers are essentially the same as, for example, shown for rays 4-8 with pixel numbers 22, 23, 24, 25, and 28. If this occurs then next thing the microprocessor does is to determine whether this group of pulses has an amplitude larger than any other consecutive groups found and which is above the signal average. Essentially as indicated in module 258, what the microprocessor does is to look at all values in the array and to determine whether there are any five other consecutive pulses having larger amplitudes and with consecutive pixel numbers. If the microprocessor does find such a group, the microprocessor will find the fire number which is the ray of the largest amplitude in the group and save this in the fire dot number as indicated in module 258. The microprocessor must find a consecutive group whose amplitude is larger than any other group found and above the signal average. As previously indicated, the microprocessor computes the signal average by adding the total value of each pixel amplitude in each of the array locations and divides by the number of memory locations in the array. This then constitutes the signal average for an entire frame. Again referring to FIG. 7, assume that after computing a signal average for the entire frame that the microprocessor computes the signal average to be 10. The microprocessor then subtracts the value of 10 from each location as, for example, from locations 0, 1, 2--N. As seen, the amplitude in ray location 1 is 9 at pixel 27. If the average signal level was 10, then this signal which is less than 10 is ignored. The value at ray location 2 would also be zero and hence be ignored and the value at ray 3 would be ignored. The value at ray 4 which is 30 would be reduced to 20. The value at 5 which is 33 would be reduced to 23, and so on. In this manner the system ignores all noise pulses in determining the location of the transducer and hence can average out and eliminate all signals which are not above the computed average amplitude. This is how the microprocessor finds the consecutive groups as indicated by module 258. If such a group is found, the microprocessor will then find the fire number of the largest amplitude in the group and save this in the fire dot number. Again referring to FIG. 7, this amplitude would be amplitude 38 for ray 6 which is the largest amplitude in the fire dot group number. In a similar manner the microprocessor will find the pixel number of the largest amplitude in the group number and save this in the dot pixel number as indicated by module 260. Again referring to FIG. 7 this will be pixel 24. The microprocessor then finds the value of the largest amplitude in the group and computes a new AGC number as indicated in module 261. Thus the largest value is 38 which, based on an average signal of 10, would be reduced to 28. Now the microprocessor is programmed with one of many, many available algorithms which essentially indicates that since the average signal was 28, it would be desired to look at a signal of twice that value. Therefore the AGC signal would now be controlled to allow the amplifier 110 of FIG. 5 to increase its gain to obtain twice the amplitude output signal. Thus this AGC number is outputted and directed, for example, to the input of the latch 136 where it is converted to a analog value based on the digital-to-analog converter 137 and as shown in module 262 of FIG. 12 to control the gain of the amplifier accordingly. After this is done, one returns from the frame interrupt program as indicated by module 263. It is also shown returning to the frame interrupt program of FIG. 12 (module 257), if the microprocessor cannot find five groups of consecutive returns in a frame whose pixel numbers are within 10 of each other, then the system provides a new AGC number that gives the maximum amplifier gain as shown in module 264. Hence if during a frame there are no consecutive pixels the microprocessor produces an output number which is stored in latch 136 which output number will be convened to an analog signal by the digital-to-analog convener 137 to operate the amplifier 110 at maximum gain. The system then makes the fire dot number non-displayable as evidenced by module 265. In this particular instance the microprocessor indicates that a transducer location could not be found during an entire frame and therefore there is no reason to operate the down-counter 134 or the dot gate 138 and therefore the dot becomes non-displayable as indicated by module 266. As one can understand, the system of FIG. 5 is constantly selecting the largest magnitude signal including the pixel number of this signal found during each line or each ray. After all these signal amplitudes are added up and averaged out, the average signal is subtracted. If the remainder does not exceed a predetermined value, there is no signal in that frame which is indicative of the presence of a transducer. This is quite possible during an ultrasonic examination by a practitioner. If this exists, then the system will operate at maximum gain until a transducer signal is found. Similarly requiring that a sequence of pulses be detected serves to ensure reliable operation. It is indicated that the above technique for producing an average signal to be subtracted from all outputs found during each ray is extremely important as it serves to substantially reduce noise and provide for reliable operation.

Claims

1. An apparatus comprising a first and a second transducer (13,10) and means therein for responding to the first transducer (13) within an area of a body, the first transducer (13) being responsive to ultrasonic energy impinging on a surface thereof emitted by the second transducer (10), said apparatus including an ultrasound imaging system (20) for imaging an area of the body, said system adapted to cause the first transducer (13) to provide return signals each time ultrasonic energy from the second transducer (10) impinges thereon, the system (20) including first means for providing a display of the area by converting imaging information into a given

number of scan lines to cover the area with the given number of scan lines indicative of a frame and second means responsive to the return signals during the frame to analyze the amplitudes of the return signals on a frame to frame basis, characterised in that the second means is adapted to provide a control signal in each frame, based on the return signal with the largest amplitude for controlling the analysis of the next succeeding frame.

2. An apparatus according to claim 1, characterised in that the means responsive to the return signals includes means (51,52,53,54) for dividing each scan line into a plurality of segments and means for indicating the segment of each line where a return signal is present to provide a pixel number for each line having a returned signal.

3. An apparatus according to claim 2, characterised in that means (33) are provided which are responsive to each of the return signals for providing and storing a representation of the amplitude of the return signals for each line during a frame.

4. An apparatus according to claim 3, characterised in that it includes means responsive to the stored amplitudes to obtain an average of the amplitude of return signals over a frame and means responsive to the average for reducing the amplitude representation as stored for each line.

5. An apparatus according to claim 4, characterised in that a selection means is responsive to the reduced stored amplitudes for selecting the largest stored amplitude for a given number of consecutive lines in a frame having pixel numbers which are less than a selected number from one another and means responsive to the selection means to provide the line number and segment number for the consecutive lines indicative of the position of the transducer.

6. An apparatus according to claim 5, characterised in that it includes means responsive to the line number and segment number to indicate the position of the transducer on the display.

7. An apparatus according to claim 1, wherein the second means are adapted to analyze the return signals corresponding to each scan line within the frame to determine which ones of the return signals are of the highest amplitude and are indicative of the location of the first transducer and to provide coordinate locations for the first transducer location.

8. An apparatus according to claim 7, characterised in that the first means for providing a display of the area includes a scan controller to image the area with a given number of scan lines per frame, with a given number of frames per second, the scan controller providing a frame start signal and a frame stop signal, with a plurality of FIRE signals located therebetween with each FIRE signal corresponding to one of the scan lines.

9. An apparatus according to claim 8, characterised in that the second means responsive to the return signals include, line counting means operative to provide a line number during the presence of the return signals indicative of a first coordinate, pixel generating means operative to divide each line into a plurality of segments and means responsive to the presence of the return signals indicative of a first coordinate to provide a pixel number indicative of a second coordinate, whereby the first and second coordinates define the first transducer location during the frame.

10. An apparatus according to claim 7, characterised in that the transducer is positioned on and secured to a catheter (12) adapted to be located in the body tissue.

11. An apparatus according to claim 1, including means coupled to the first transducer for measuring a predetermined signal characteristic from the signals emitted by the second transducer during a frame and means responsive to signals emitted by the first transducer to provide an X and Y coordinate for a maximum measured value of the signal characteristic within the scanned area for each frame.

12. An apparatus according to claim 11, characterised in that means responsive to the X and Y coordinates are provided for inserting a marker indication on the display (21) for each frame indicative of the location of the maximum measured value and therefore the first transducer.

13. An apparatus according to claim 12, characterised in that means are provided which are responsive to the first transducer signal to compare it with a threshold, wherein if any of the first transducer signal exceeds the threshold a control signal is provided and means responsive to the control signal for storing the value of the first transducer signal as exceeding the threshold.

14. An apparatus according to claim 1, wherein the first means includes a scan controller and the second means (35) compares the return signal with other emitted signals to detect larger amplitude emitted signals during a line and third means (33) are provided responsive to the detection of larger emitted signals during each line for providing an X and Y coordinate indicative of the larger amplitude emit-

ted signals for each line in a frame, fourth means are provided, responsive to the larger emitted signals and the X and Y coordinate, for storing the larger amplitude emitted signals during the frame, and means are provided responsive to the stored signals for selecting those signals indicative of the location of the transducer during the frame.

15. An apparatus according to claim 14, characterised in that the first means includes an amplifier (31) for amplifying the emitted signal at an output terminal and an analog to digital converter (32) having an input coupled to the output terminal for providing a digital signal at an output of a value indicative of the amplitude of the emitted signal.

16. An apparatus according to claim 15, characterised in that the second means includes a first comparator (34) having an input coupled to a noise level digital number and a second input coupled to the output of the analog to digital converter (32) to provide an output signal when the second input exceeds the first input and a latch (33) responsive to the output signal for storing the value of the emitted signal.

17. An apparatus according to claim 16, characterised in that the third means includes a second comparator (35) having one input coupled to the transducer and another input coupled to the output of the analog to digital converter (32) for comparing value of the emitted signal stored within the latch (33) with the values of new emitted signals from the analog to digital converter (32) and for providing an output signal when the new emitted signal value exceeds the value of the emitted signal stored within the latch (33) and means for causing the latch to store the value of the new emitted signal whereby the latch (33) will have stored therein the largest value of the emitted signal produced with the frame.

18. An apparatus according to claim 17, characterised in that the fourth means includes a first counter (41) or counting each scan line during a frame and means (42) coupled to the counter for storing the counted line during the detection of the largest signal, and indicative of the X coordinate and a second means (51) operative to divide each of the lines into segments and including means for storing (52) the segment during the detection of the largest signal indicative of a Y coordinate.

19. An apparatus according to claim 14, characterised in that it further includes means (75) for comparing the X coordinates for the previous frame with the present frame and providing an output when they are equal, means responsive to the output for inserting a signal into the imaging signal to mark the location of the catheter.

20. An apparatus according to Claim 16, characterized in that it includes digital to analog converter (39) having an input coupled to the output of the latch (33) for providing an analog signal at an output terminal, with the output terminal coupled to the amplifying means (31) for controlling the gain thereof according to the value of the stored signal.

21. An apparatus according to Claim 14, characterized in that it includes a video display coupled to the scan controller for providing a video display of each frame and a marker coupled to the fourth means for highlighting the X-Y coordinate location on the display to distinguish the location of the object from the remainder of the display.

22. An apparatus according to Claim 21, characterized in that the marker includes means for causing the X and Y coordinate location to blink.

23. An apparatus according to Claim 21, characterized in that the marker includes means for providing a color indication at the X and Y coordinate location.

Patentansprüche

1. Eine Einrichtung mit einem ersten Wandler und einem zweiten Wandler (13, 10) und Mitteln darin zum Antworten auf den ersten Wandler (13) innerhalb eines Bereichs eines Körpers, wobei der erste Wandler (13) auf von dem zweiten Wandler (10) emittierte Ultraschallenergie, die auf seine Oberfläche auftrifft, anspricht, wobei die Einrichtung ein Ultraschallbildgebungssystem (20) zum Abbilden eines Bereichs des Körpers enthält, wobei das System so ausgebildet ist, daß es den ersten Wandler (13) veranlaßt, jedesmal dann Rückgabesignale zur Verfügung zu stellen, wenn Ultraschallenergie aus dem zweiten Wandler (10) auf ihn auftrifft, wobei das System (20) erste Mittel zum Bereitstellen einer Anzeige des Bereichs durch Konvertieren von Abbildungsinformationen in eine vorgegebene Anzahl von Abtastzeilen enthält, wobei die vorgegebene Anzahl von Abtastzeilen den Bereich abdecken soll, wobei die vorgegebene Anzahl von Abtastzeilen ein Einzelbild anzeigt, und wobei das System zweite Mittel enthält, die auf die Rückgabesignale während des Einzelbildes ansprechen, um die Amplituden der Rückkehrsignale Einzelbild für Einzelbild zu analysieren, dadurch gekennzeichnet, daß die zweiten Mittel so ausgebildet sind, daß sie ein Steuersignal in jedem Einzelbild auf der Basis des Rückgabesignals mit der größten Amplitude zum Steuern der Analyse des nächstfolgenden Einzelbildes zur Verfügung stellen.

2. Eine Einrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die auf die Rückgabesignale ansprechenden Mittel Mittel (51, 52, 53, 54) zum Aufteilen jeder Abtastzeile in eine Mehrzahl von Segmenten und Mittel zum Kennzeichnen des Segments jeder Zeile, in dem ein Rückgabesignal vorhanden ist, enthalten, um eine Pixelnummer für jede Zeile zur Verfügung zu stellen, die ein zurückgegebenes Signal aufweist.

3. Eine Einrichtung nach Anspruch 2, dadurch gekennzeichnet, daß Mittel (33) vorgesehen sind, welche auf jedes der Rückgabesignale ansprechen, um eine Darstellung der Amplitude der Rückgabesignale für jede Zeile während eines Einzelbildes zur Verfügung zu stellen und zu speichern.

4. Eine Einrichtung nach Anspruch 3, dadurch gekennzeichnet, daß sie auf die gespeicherten Amplituden ansprechende Mittel zum Erlangen eines Mittelwerts der Amplitude der Rückgabesignale über ein Einzelbild und auf den Durchschnitt ansprechende Mittel zum Reduzieren der für jede Zeile gespeicherten Amplitudendarstellung enthält.

5. Eine Einrichtung nach Anspruch 4, gekennzeichnet dadurch, daß ein Auswahlmittel auf die reduzierten gespeicherten Amplituden anspricht, um die größte gespeicherte Amplitude für eine gegebene Anzahl von aufeinanderfolgenden Zeilen in einem Einzelbild auszuwählen, die Pixelnummern aufweisen, welche geringer sind, als eine ausgewählte Nummer von einer anderen, und durch auf das Auswahlmittel ansprechende Mittel zum Bereitstellen der Zeilennummer und Segmentnummer für die aufeinanderfolgenden Zeilen, die die Position des Wandlers kennzeichnen.

6. Eine Einrichtung nach Anspruch 5, dadurch gekennzeichnet, daß sie auf die Zeilennummer und Segmentnummer ansprechende Mittel zum Anzeigen der Position des Wandlers auf dem Display enthält.

7. Eine Einrichtung nach Anspruch 1, wobei die zweiten Mittel so ausgebildet sind, daß sie die jeder Abtastzeile innerhalb des Einzelbildes entsprechenden Rückgabesignale analysieren, um zu bestimmen, welcher der Rückgabesignale die höchste Amplitude aufweisen und den Ort des ersten Wandlers kennzeichnen, und um Koordinatenorte für den Ort des ersten Wandlers zur Verfügung zu stellen.

8. Eine Einrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die ersten Mittel zum Bereitstellen einer Anzeige des Bereichs eine Abtaststeuereinrichtung enthalten, um den Bereich mit einer vorgegebenen Anzahl von Abtastzeilen pro Einzelbild bei einer vorgegebenen Anzahl von Einzelbildern pro Sekunde abzubilden, wobei die Abtaststeuereinrichtung ein Einzelbildstartsignal und ein Einzelbildstopsignal zur Verfügung stellt, wobei eine Mehrzahl von FIRE-Signalen dazwischen angeordnet ist, wobei jedes FIRE-Signal einer der Abtastzeilen entspricht.

9. Eine Einrichtung nach Anspruch 8, dadurch gekennzeichnet, daß die auf die Rückgabesignale ansprechenden zweiten Mittel Zeilenzählmittel, die eine Zeilennummer während des Vorhandenseins der Rückgabesignale zur Verfügung stellen können, die eine erste Koordinate anzeigt, Pixelerzeugungsmittel, die jede Zeile in eine Mehrzahl von Segmenten unterteilen können, und Mittel, die auf das Vorhandensein der Rückgabesignale ansprechen, die eine erste Koordinate kennzeichnen, um eine Pixelnummer zur Verfügung stellen, die eine zweite Koordinate anzeigt, enthalten, wodurch die erste und die zweite Koordinate den Ort des ersten Wandlers während des Einzelbildes definieren.

10. Eine Einrichtung nach Anspruch 7, dadurch gekennzeichnet, daß der Wandler auf einem Katheter (12) positioniert und daran befestigt ist, wobei das Katheter so ausgebildet ist, daß es in dem Körpergewebe angeordnet sein kann.

11. Eine Einrichtung nach Anspruch 1, aufweisend mit dem ersten Wandler gekoppelte Mittel zum Messen einer vorgegebenen Signalcharakteristik der von dem zweiten Wandler während eines Einzelbilds emittierten Signale und auf die von dem ersten Wandler emittierten Signale ansprechende Mittel zum Bereitstellen einer X- und einer Y-Koordinate für einen gemessenen Maximalwert der Signalcharakteristik innerhalb des abgetasteten Bereichs für jedes Einzelbild.

12. Eine Einrichtung nach Anspruch 11, dadurch gekennzeichnet, daß die auf die X- und Y-Koordinaten ansprechenden Mittel bereitgestellt werden, um eine Markierkennzeichnung auf dem Display (21) für jedes Einzelbild zur Verfügung zu stellen, die den Ort des maximal gemessenen Werts und folglich des ersten Wandlers anzeigt.

13. Eine Einrichtung nach Anspruch 12, dadurch gekennzeichnet, daß Mittel bereitgestellt werden, welche auf das erste Wandlersignal ansprechen, um es mit einem Schwellenwert zu vergleichen, wobei dann, wenn das Signal des ersten Wandlers den Schwellenwert überschreitet, ein Steuersignal zur Verfügung gestellt wird, und daß auf das Steuersignal ansprechende Mittel zum Speichern des Werts des ersten Wandlersignals, wenn es den

Schwellenwert überschreitet, zur Verfügung gestellt werden.

14. Eine Einrichtung nach Anspruch 1, wobei die ersten Mittel eine Abtaststeuereinrichtung enthalten und die zweiten Mittel (35) das Rückgabesignal mit anderen emittierten Signalen vergleichen, um emittierte Signale größerer Amplitude während einer Zeile zu erfassen, und das dritte Mittel (33) vorgesehen sind, die auf die Erfassung der größeren emittierten Signale während jeder Zeile ansprechen, um eine X-und Y-Koordinate bereitzustellen, die die emittierten Signale größerer Amplitude für jede Zeile in einem Einzelbild kennzeichnen, wobei vierte Mittel vorgesehen sind, die auf die größeren emittierten Signale und die X- und Y-Koordinaten ansprechen, zum Speichern der emittierten Signale größerer Amplitude während des Einzelbilds, und wobei Mittel vorgesehen sind, die auf die gespeicherten Signale ansprechen, um diejenigen Signale auszuwählen, die den Ort des Wandlers während des Einzelbilds anzeigen.

15. Eine Einrichtung nach Anspruch 14, dadurch gekennzeichnet, daß die ersten Mittel einen Verstärker (31) zum Verstärken des emittierten Signals an einem Ausgangsanschluß und einen Analog-zu-Digital-Umsetzer (32) mit einem mit dem Ausgangsanschluß gekoppelten Eingang zum Bereitstellen eines den die Amplitude des emittierten Signals anzeigenden Wert aufweisenden Digitalsignals an einem Ausgang enthalten.

16. Eine Einrichtung nach Anspruch 15, dadurch gekennzeichnet, daß die zweiten Mittel einen ersten Komparator (34) enthalten, der einen Eingang aufweist, der mit einer Rauschpegeldigitalzahl gekoppelt ist, und einen mit dem Ausgang des Analog-zu-Digital-Umsetzers (32) gekoppelten zweiten Eingang, um ein Ausgangssignal bereitzustellen, wenn das zweite Eingangssignal das erste Eingangssignal überschreitet, und ein auf das Ausgangssignal ansprechendes Latch (33) zum Speichern des Werts des emittierten Signals.

17. Eine Einrichtung nach Anspruch 16, dadurch gekennzeichnet, daß die dritten Mittel einen zweiten Komparator (35) enthalten, der einen mit dem Wandler gekoppelten Eingang und einen mit dem Ausgang des Analog-zu-Digital-Umsetzers (32) gekoppelten weiteren Eingang aufweist, um den Wert des in dem Latch (33) gespeicherten emittierten Signals mit den Werten der neu emittierten Signale aus dem Analog-zu-Digital-Umsetzer (32) zu vergleichen und um ein Ausgangssignal zur Verfügung zu stellen, wenn der neu emittierte Signalwert den in dem Latch (33) gespeicherten Wert des emittierten Signals überschreitet, und Mittel, die das Latch veranlassen, den Wert des neu emittierten Signals zu speichern, wodurch das Latch (33) in sich den größten Wert des bei dem Einzelbild erzeugten emittierten Signals speichert.

18. Eine Einrichtung nach Anspruch 17, dadurch gekennzeichnet, daß die vierten Mittel einen ersten Zähler (41) zum Zählen jeder Abtastzeile während eines Einzelbilds und mit dem Zähler gekoppelte Mittel (42) zum Speichern der gezählten Zeile während der Erfassung des größten Signals, die die X-Koordinate anzeigen, enthalten, und ein zweites Mittel (51), das jede der Zeilen in Segmente unterteilen kann und Mittel zum Speichern (52) des Segments während der Erfassung des größten Signals enthält, das eine Y-Koordinate anzeigt.

19. Eine Einrichtung nach Anspruch 17, dadurch gekennzeichnet, daß sie ferner Mittel (75) zum Vergleichen der X-Koordinaten des vorhergehenden Einzelbilds mit denen des gegenwärtigen Einzelbilds und zum Bereitstellen eines Ausgangssignals, wenn diese gleich sind, und auf das Ausgangssignal ansprechende Mittel zum Einfügen eines Signals in das Bildsignal zum Markieren des Ortes des Katheters enthalten.

20. Eine Einrichtung nach Anspruch 16, dadurch gekennzeichnet, daß sie einen Digital-zu-Analog-Umsetzer (39) enthält, der einen Eingang aufweist, der mit dem Ausgang des Latch (33) gekoppelt ist, zum Bereitstellen eines Analogsignals an einem Ausgangsanschluß, wobei der Ausgangsanschluß mit den Verstärkungsmitteln (31) zum Steuern der Verstärkung dieser Verstärkungsmittel gemäß dem Wert des gespeicherten Signals gekoppelt ist.

21. Eine Einrichtung nach Anspruch 14, dadurch gekennzeichnet, daß sie ein mit der Abtaststeuereinrichtung gekoppeltes Videodisplay zum Bereitstellen einer Videoanzeige für jedes Einzelbild und eine mit den vierten Mitteln gekoppelte Markierung zum Hervorheben des X-Y-Koordinantenortes auf der Anzeige zum Unterscheiden des Ortes des Objekts von dem Rest der Anzeige enthält.

22. Eine Einrichtung nach Anspruch 21, dadurch gekennzeichnet, daß die Markierung Mittel enthält, die ein Blinken des X- und Y-Koordinatenortes bewirken.

23. Eine Einrichtung nach Anspruch 21, dadurch gekennzeichnet, daß die Markierung Mittel enthält, die eine Farbkennzeichnung an dem X- und Y-Koordinatenort bereitstellen.

Revendications

1. Un appareil comprenant un premier et un deuxième transducteurs (13, 10) et contenant un moyen pour répondre au premier transducteur (13) à l'intérieur d'une zone d'un corps, le premier transducteur (13) répondant à une énergie ultrasonique qui frappe l'une de ses surfaces et est émise par le deuxième transducteur (10), ledit appareil incluant un système d'imagerie ultrasonique (20) pour effectuer une image d'une zone du corps, ledit système étant apte à amener le premier transducteur (13) à envoyer des signaux de renvoi chaque fois qu'une énergie ultrasonique venant du deuxième transducteur (10) le frappe, le système (20) incluant un premier moyen pour réaliser un affichage de la zone en convertissant l'information d'imagerie en un nombre donné de lignes de balayage afin de couvrir la zone au moyen du nombre donné de lignes de balayage indicatives d'une trame, et un deuxième moyen qui répond aux signaux de renvoi pendant la trame pour analyser les amplitudes des signaux de renvoi sur une base trame par trame, caractérisé en ce que le deuxième moyen est apte à engendrer dans chaque trame un signal de commande basé sur le signal de renvoi dont l'amplitude est maximale, afin de commander l'analyse de la trame immédiatement suivante.

2. Un appareil selon la revendication 1, caractérisé en ce que le moyen qui répond aux signaux de renvoi inclut un moyen (51, 52, 53, 54) de division de chaque ligne de balayage en une série de segments et un moyen destiné à indiquer le segment de chaque ligne où un signal de renvoi est présent afin d'engendrer un numéro de pixel pour chaque ligne qui possède un signal renvoyé.

3. Un appareil selon la revendication 2, caractérisé en ce qu'un moyen (33) qui répond à chacun des signaux de renvoi, pour engendrer et mémoriser une représentation de l'amplitude des signaux de renvoi pour chaque ligne pendant une trame, est agencé.

4. Un appareil selon la revendication 3, caractérisé en ce qu'il inclut un moyen qui répond aux amplitudes mémorisées afin d'obtenir une moyenne de l'amplitude des signaux de renvoi sur une trame et un moyen qui répond à la moyenne pour réduire la représentation d'amplitude, telle qu'elle est mémorisée pour chaque ligne.

5. Un appareil selon la revendication 4, caractérisé en ce qu'un moyen de sélection répond aux amplitudes mémorisées réduites pour sélectionner l'amplitude mémorisée maximale pour un nombre donné de lignes consécutives d'une trame pourvues de numéros de pixels qui sont inférieurs à un nombre sélectionné de l'une à l'autre et un moyen qui répond au moyen de sélection pour fournir le numéro de ligne et les numéros de segment pour les lignes consécutives qui sont indicatifs de la position du transducteur.

6. Un appareil selon la revendication 5, caractérisé en ce qu'il inclut un moyen qui répond au numéro de ligne ou au numéro de segment pour indiquer sur l'affichage la position du transducteur.

7. Un appareil selon la revendication 1, dans lequel le deuxième moyen est apte à analyser les signaux de renvoi qui correspondent à chaque ligne de balayage à l'intérieur de la trame afin de déterminer ceux des signaux de renvoi qui sont d'une amplitude maximale et sont indicatifs de la localisation du premier transducteur et de fournir des coordonnées de localisation pour la localisation du premier transducteur.

8. Un appareil selon la revendication 7, caractérisé en ce que le premier moyen d'agencement d'un affichage de la zone inclut un dispositif de commande de balayage pour effectuer l'imagerie de la zone au moyen d'un nombre donné de lignes de balayage par trame, à un nombre donné de trames par seconde, le dispositif de commande de balayage envoyant un signal de début de trame et un signal d'arrêt de trame, une série de signaux de DECLENCHEMENT étant intercalés entre eux et chaque signal de DECLENCHEMENT correspondant à l'une des lignes de balayage.

9. Un appareil selon la revendication 8, caractérisé en ce que le deuxième moyen qui répond aux signaux de renvoi inclut un moyen de comptage de lignes qui peut intervenir pour fournir un numéro de ligne lorsque les signaux de renvoi indicatifs d'une première coordonnée sont présents, un moyen générateur de pixels, qui peut intervenir pour diviser chaque ligne en une série de segments et un moyen qui répond à la présence des signaux de renvoi indicatifs d'une première coordonnée pour fournir un numéro de pixel indicatif d'une deuxième coordonnée, d'une manière telle que la première et la deuxième coordonnées définissent la localisation du premier transducteur pendant la trame.

10. Un appareil selon la revendication 7, caractérisé en ce que le transducteur est positionné et fixé sur un cathéter (12) apte à être situé dans le tissu du corps.

11. Un appareil selon la revendication 1, qui inclut un moyen couplé au premier transducteur pour mesurer une caractéristique prédéterminée de signal à

partir des signaux émis par le deuxième transducteur pendant une trame et un moyen qui répond à des signaux émis par le premier transducteur pour fournir une coordonnée X et Y pour une valeur mesurée maximale de la caractéristique de signal à l'intérieur de la zone balayée pour chaque trame.

12. Un appareil selon la revendication 11, caractérisé en ce qu'un moyen qui répond aux coordonnées X et Y est agencé de manière à insérer une indication de marqueur sur l'affichage (21) pour chaque trame indicative de la localisation de la valeur mesurée maximale et donc du premier transducteur.

13. Un appareil selon la revendication 12, caractérisé en ce qu'un moyen qui répond au premier signal de transducteur pour le comparer à un seuil est agencé, un signal de commande étant engendré si un quelconque signal du premier transducteur dépasse le seuil, et un moyen qui répond au signal de commande pour mémoriser la valeur du signal du premier transducteur comme dépassant le seuil est aussi agencé.

14. Un appareil selon la revendication 1, dans lequel le premier moyen inclut un dispositif de commande de balayage et le deuxième moyen (35) compare le signal de renvoi à d'autres signaux émis afin de détecter des signaux émis d'amplitude supérieure pendant une ligne et un troisième moyen (33) est agencé pour répondre à la détection de signaux émis supérieurs pendant chaque ligne pour fournir une coordonnée X et Y indicative des signaux émis d'amplitude supérieure pour chaque li d'une trame, un quatrième moyen est agencé pour répondre aux signaux émis supérieurs et à la coordonnée X et Y, afin de mémoriser des signaux d'amplitude supérieure émis pendant la trame, et un moyen est agencé pour répondre aux signaux mémorisés afin de sélectionner les signaux indicatifs de la localisation du transducteur pendant la trame.

15. Un appareil selon la revendication 14, caractérisé en ce que le premier moyen inclut un amplificateur (31) pour amplifier le signal émis à une borne de sortie et un convertisseur (32) d'analogique à numérique dont une entrée est couplée à la borne de sortie pour fournir à une sortie un signal numérique d'une valeur indicative d'une valeur indicative de l'amplitude du signal émis.

16. Un appareil selon la revendication 15, caractérisé en ce que le deuxième moyen inclut un premier comparateur (34) dont une entrée est couplée à un nombre numérique de niveau de bruit et une deuxième entrée est couplée à la sortie du convertisseur (32) d'analogique à numérique pour engendrer un signal de sortie lorsque la deuxième entrée dépasse la première entrée et un sas (33) qui répond au signal de sortie pour mémoriser la valeur du signal émis.

17. Un appareil selon la revendication 16, caractérisé en ce que le troisième moyen inclut un deuxième comparateur (35) dont une entrée est couplée au transducteur et une autre entrée est couplée à la sortie du convertisseur (32) d'analogique à numérique pour comparer une valeur du signal émis mémorisée à l'intérieur du sas (33) aux valeurs de nouveaux signaux émis provenant du convertisseur (32) d'analogique à numérique et pour engendrer un signal de sortie lorsque la valeur du nouveau signal émis dépasse la valeur du signal émis mémorisé à l'intérieur du sas (33) et un moyen destiné à amener le sas à mémoriser la valeur du nouveau signal émis, d'une manière telle que la valeur maximale du signal émis produit par la trame sera mémorisée dans le sas (33).

18. Un appareil selon la revendication 17, caractérisé en ce que le quatrième moyen inclut un premier compteur (41) pour compter chaque ligne de balayage pendant une trame et un moyen (42) couplé au compteur pour mémoriser la ligne comptée pendant la sélection du signal qui est maximal et indicatif de la coordonnée X et un deuxième moyen (51) qui peut intervenir pour diviser chacune des lignes en segments et inclut un moyen pour mémoriser (52) le segment pendant la détection du signal maximal indicatif d'une coordonnée Y.

19. Un appareil selon la revendication 14, caractérisé en ce qu'il inclut en outre un moyen (75) pour comparer les coordonnées X de la trame précédente à la trame actuelle et pour engendrer une sortie lorsqu'elles sont égales, un moyen qui répond à la sortie pour insérer un signal dans le signal d'imagerie afin de marquer la localisation du cathéter.

20. Un appareil selon la revendication 16, caractérisé en ce qu'il inclut un convertisseur (39) de numérique à analogique dont une entrée est couplée à la sortie du sas (33) pour envoyer un signal analogique à une borne de sortie, la borne de sortie étant couplée au moyen amplificateur (31) pour commander son gain en fonction de la valeur du signal mémorisé.

21. Un appareil selon la revendication 14, caractérisé en ce qu'il inclut un affichage vidéo couplé au dispositif de commande de balayage pour produire un affichage vidéo de chaque trame et un marquer couplé au quatrième moyen pour accentuer la localisation de coordonnées X-Y sur l'affichage afin de distinguer la localisation de l'objet par rapport au reste de l'affichage.

22. Un appareil selon la revendication 21, caractérisé en ce que le marquer inclut un moyen destiné à amener la localisation de coordonnées X et Y à clignoter.

23. Un appareil selon la revendication 21 caractérisé en ce que le marquer inclut un moyen destiné à fournir une indication en couleurs à la localisation de coordonnées X et y.

FIG—1

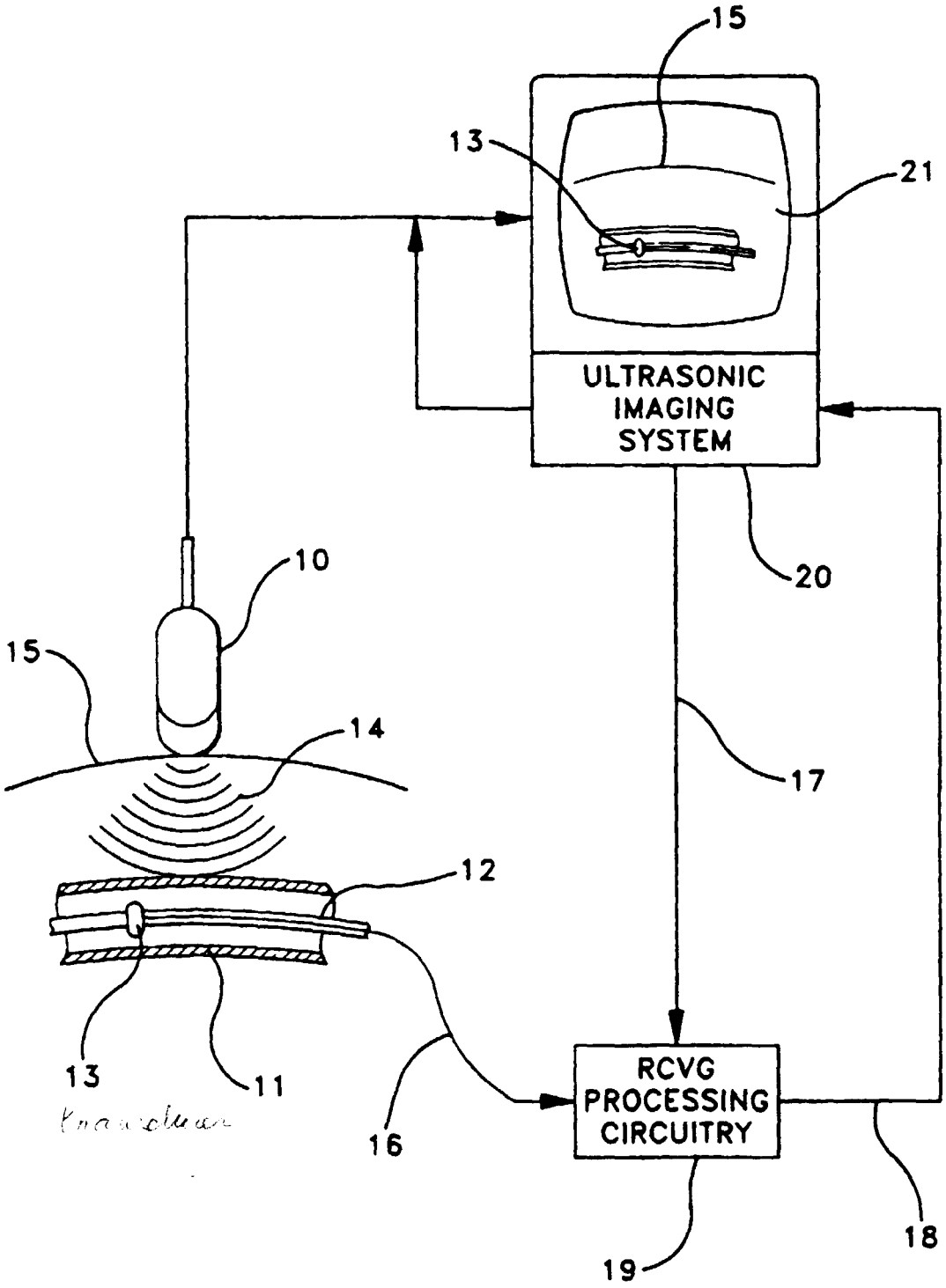

15
13
21
ULTRASONIC
IMAGING
SYSTEM
20
10
15
14
17
12
13
11
16
RCVG
PROCESSING
CIRCUITRY
18
19

FIG-2

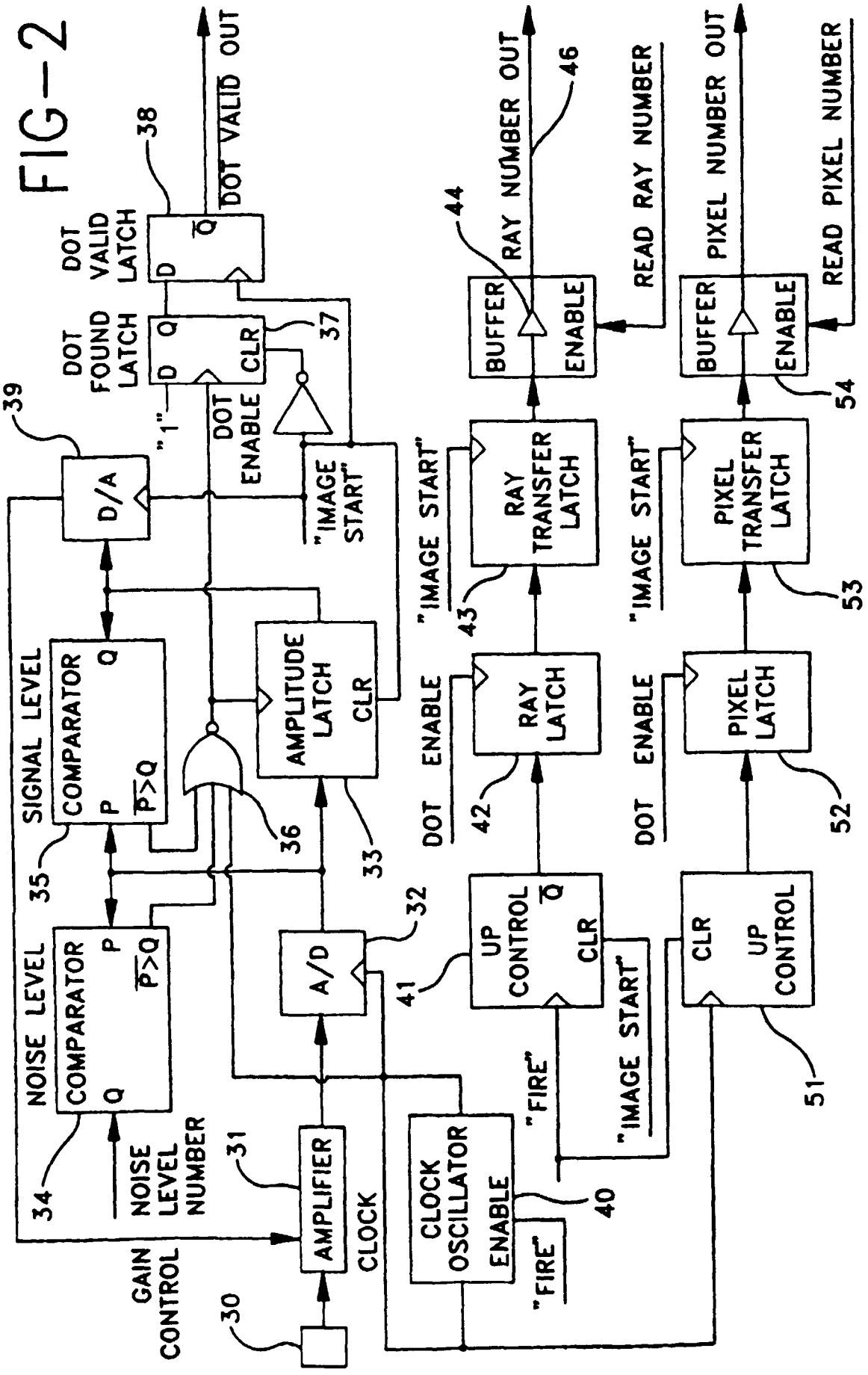

DOT VALID OUT
38
DOT VALID LATCH
DOT FOUND LATCH
37
"1"
DOT ENABLE
"IMAGE START"
39
D/A
SIGNAL LEVEL
COMPARATOR
35
P>Q
36
AMPLITUDE LATCH
CLR
33
NOISE LEVEL
COMPARATOR
34
NOISE LEVEL NUMBER
31
AMPLIFIER
GAIN CONTROL
30
CLOCK
A/D
32
CLOCK OSCILLATOR
ENABLE
"FIRE"
40
UP CONTROL
41
"FIRE"
"IMAGE START"
DOT ENABLE
42
RAY LATCH
"IMAGE START"
43
RAY TRANSFER LATCH
BUFFER
ENABLE
44
RAY NUMBER OUT
46
READ RAY NUMBER
DOT ENABLE
52
PIXEL LATCH
"IMAGE START"
53
PIXEL TRANSFER LATCH
BUFFER
ENABLE
54
PIXEL NUMBER OUT
READ PIXEL NUMBER
CLR
UP CONTROL
51

FIG-3

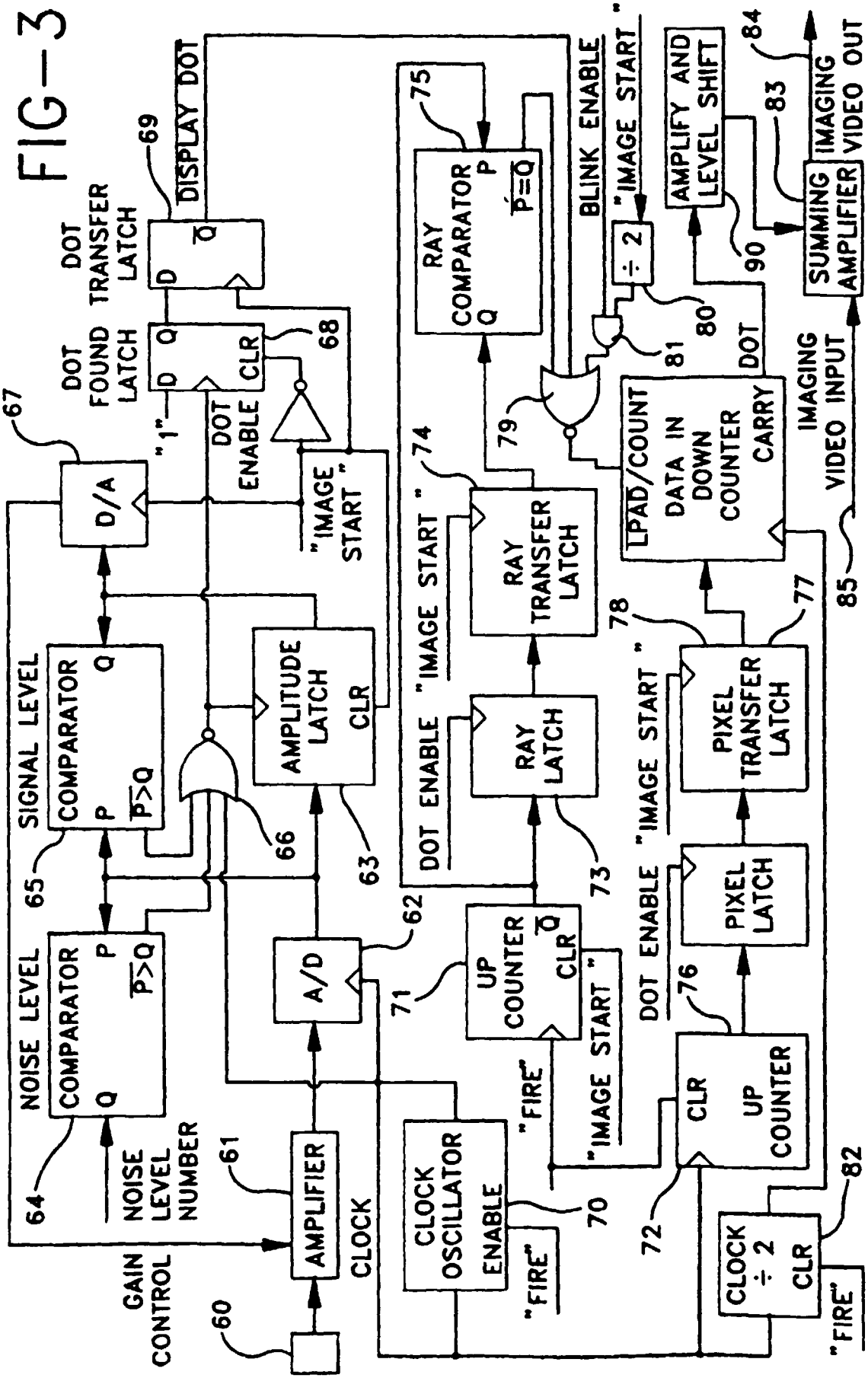
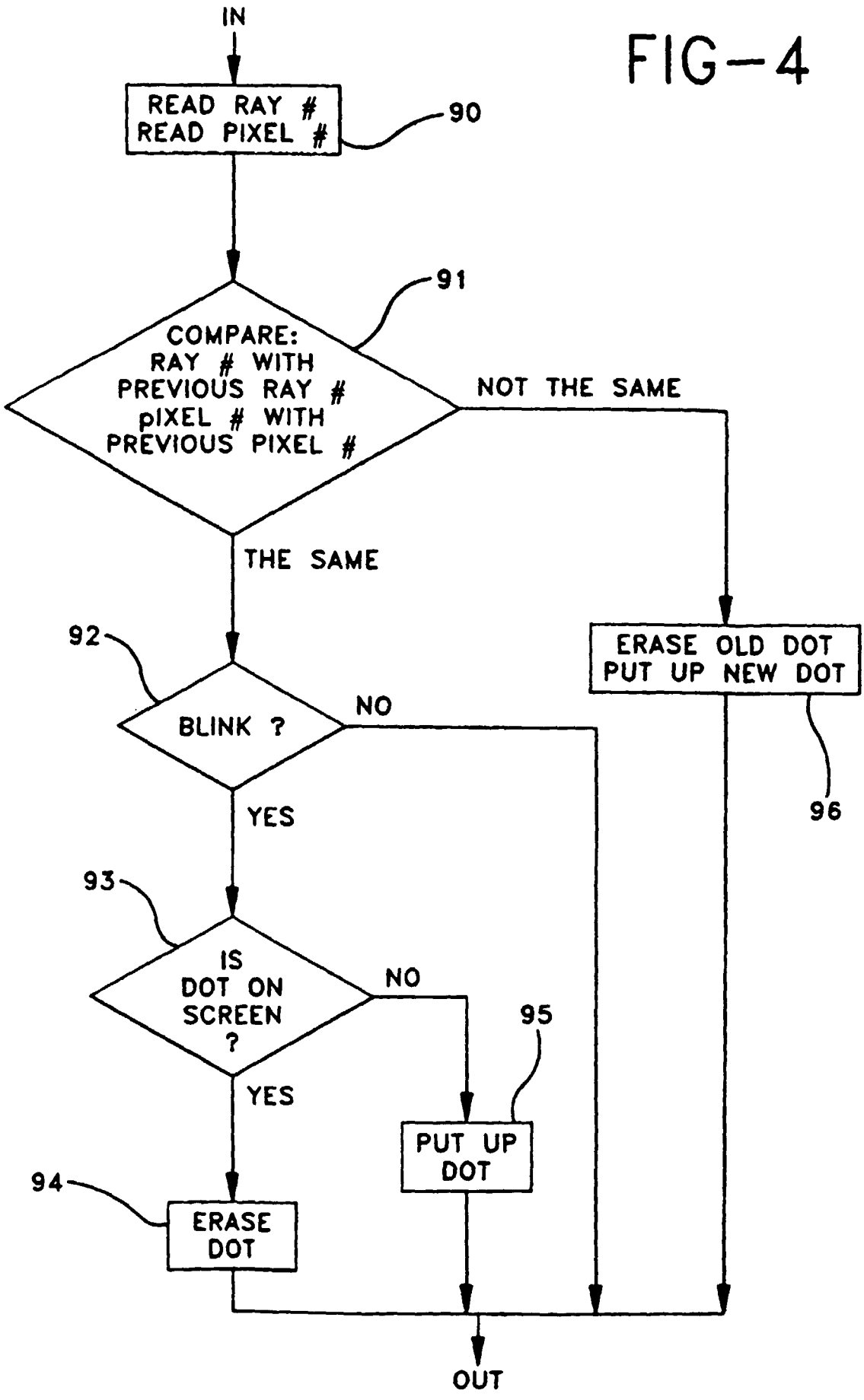

NOISE LEVEL COMPARATOR
SIGNAL LEVEL COMPARATOR
NOISE LEVEL NUMBER
GAIN CONTROL
AMPLIFIER
CLOCK
A/D
D/A
AMPLITUDE LATCH
CLR
DOT FOUND LATCH
DOT TRANSFER LATCH
DISPLAY DOT
"1"
DOT ENABLE
"IMAGE START"
CLOCK OSCILLATOR
ENABLE
"FIRE"
UP COUNTER
RAY COMPARATOR
RAY TRANSFER LATCH
RAY LATCH
DOT ENABLE "IMAGE START"
BLINK ENABLE
÷ 2
LPAD/COUNT
DATA IN
DOWN COUNTER
CARRY
DOT
IMAGING VIDEO INPUT
PIXEL TRANSFER LATCH
PIXEL LATCH
AMPLIFY AND LEVEL SHIFT
SUMMING AMPLIFIER
IMAGING VIDEO OUT
CLOCK ÷ 2
CLR
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
90

FIG-4


IN
READ RAY #
READ PIXEL #
90
91
COMPARE:
RAY # WITH
PREVIOUS RAY #
pIXEL # WITH
PREVIOUS PIXEL #
NOT THE SAME
THE SAME
92
BLINK ?
NO
YES
ERASE OLD DOT
PUT UP NEW DOT
96
93
IS
DOT ON
SCREEN
?
NO
YES
95
PUT UP
DOT
94
ERASE
DOT
OUT

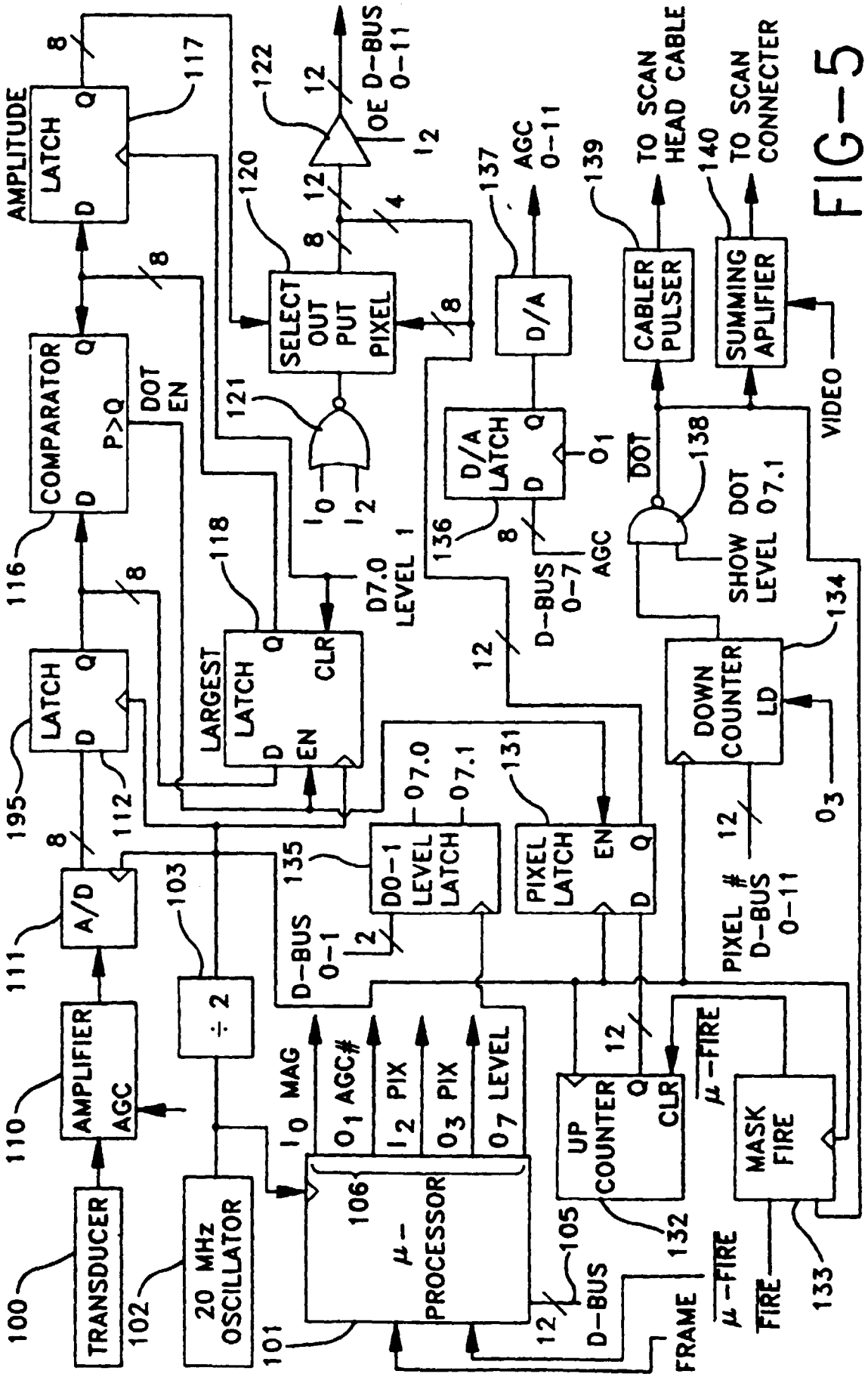

AMPLITUDE LATCH
COMPARATOR
LATCH
A/D
AMPLIFIER
AGC
÷ 2
TRANSDUCER
20 MHz OSCILLATOR
LARGEST LATCH
SELECT OUT PUT PIXEL
OE D-BUS 0-11
D7.0 LEVEL 1
D/A LATCH
D/A
AGC 0-11
CABLER PULSER
TO SCAN HEAD CABLE
SUMMING APLIFIER
TO SCAN CONNECTER
VIDEO
SHOW DOT LEVEL 07.1
DOT
AGC
D-BUS 0-7
DOWN COUNTER
PIXEL # D-BUS 0-11
D0-1 LEVEL LATCH
PIXEL LATCH
D-BUS 0-1
μ-PROCESSOR
I0 MAG
O1 AGC#
I2 PIX
O3 PIX
O7 LEVEL
UP COUNTER
MASK FIRE
μ-FIRE
FIRE
FRAME
D-BUS
100
102
101
106
110
111
103
195
112
116
118
117
120
121
122
136
137
139
138
140
134
135
131
105
132
133

FIG-5

FIG-6

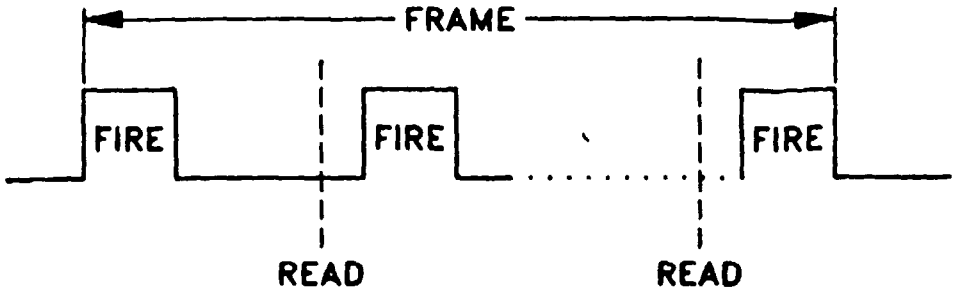


FIG-7

FIRE # (RAY)

	0	1	2	3	4	5	6	7	8 ..... N
AMP	6	9	10	3	30	33	38	34	35
PIXEL Y (COO)	13	27	41	52	22	23	24	25	28

FIG-8A

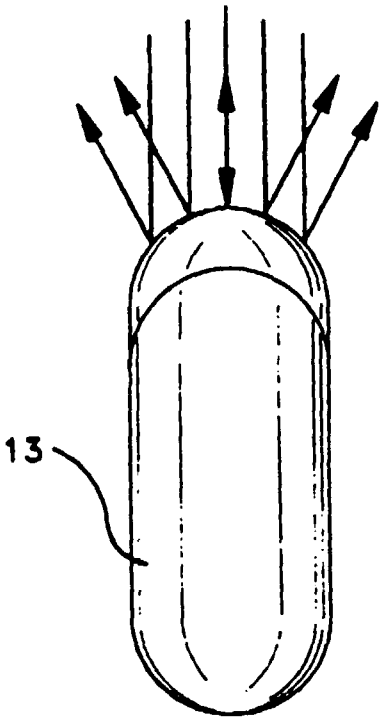
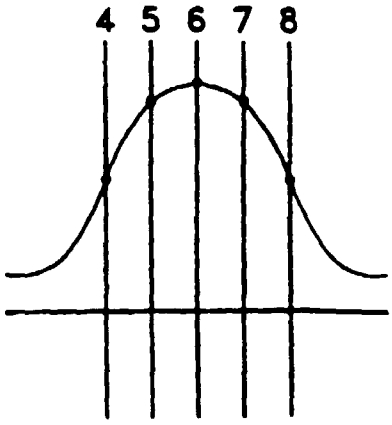


FIG-8B



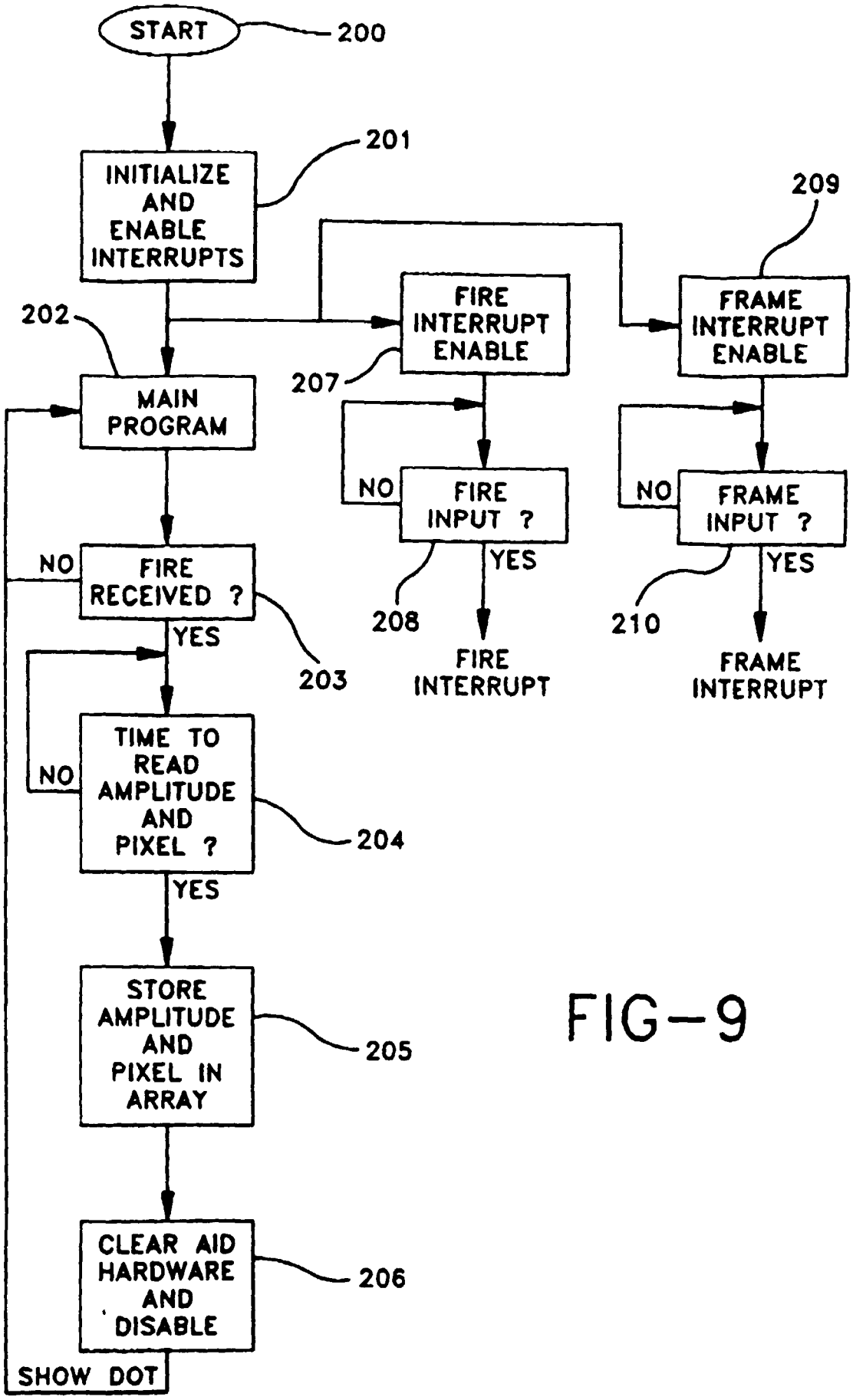

START
200
INITIALIZE AND ENABLE INTERRUPTS
201
202
MAIN PROGRAM
NO
FIRE RECEIVED ?
YES
203
TIME TO READ AMPLITUDE AND PIXEL ?
NO
YES
204
STORE AMPLITUDE AND PIXEL IN ARRAY
205
CLEAR AID HARDWARE AND DISABLE
206
SHOW DOT
FIRE INTERRUPT ENABLE
207
NO
FIRE INPUT ?
YES
208
FIRE INTERRUPT
209
FRAME INTERRUPT ENABLE
NO
FRAME INPUT ?
YES
210
FRAME INTERRUPT

FIG-9

FIG-10

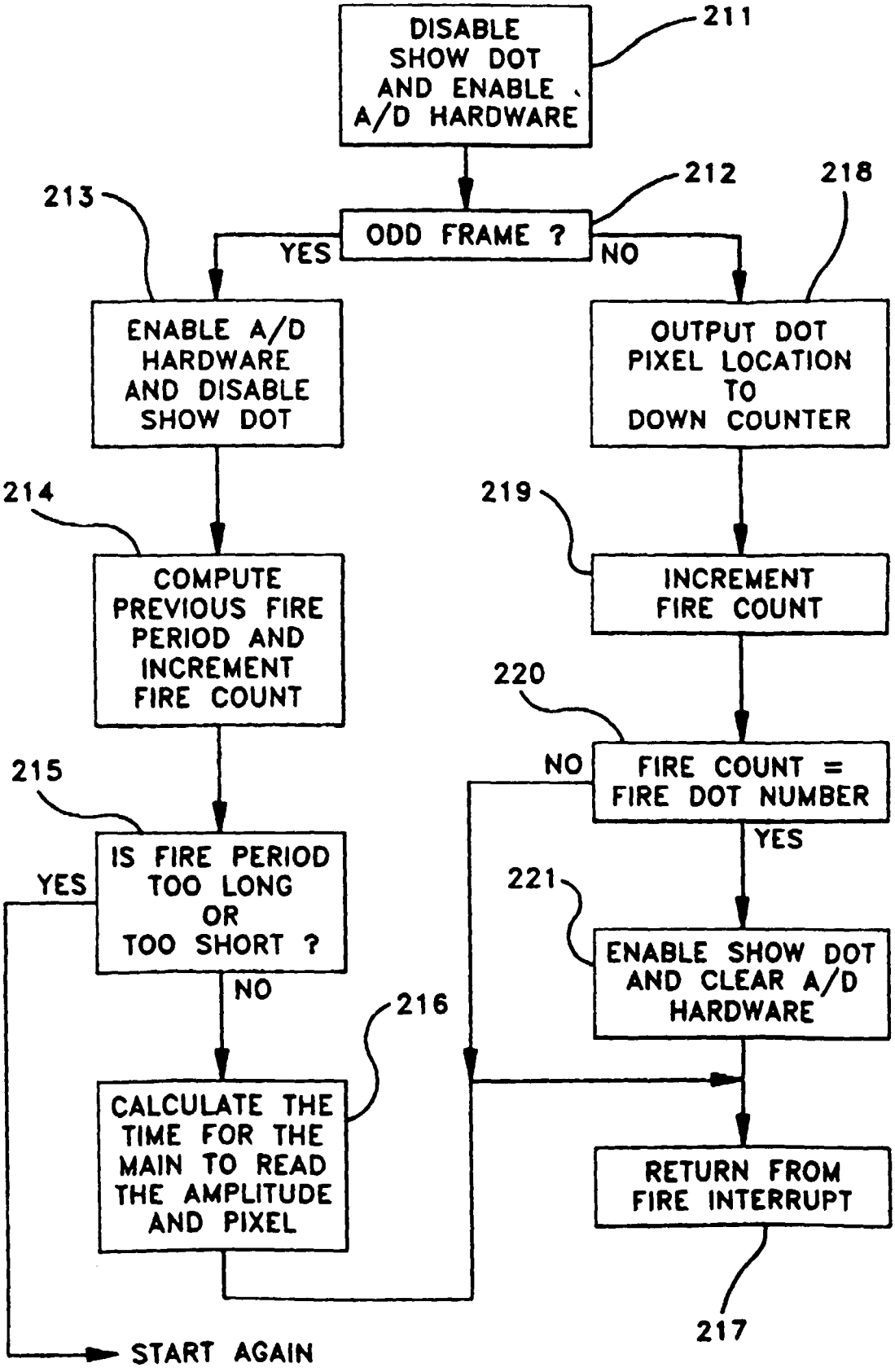

DISABLE SHOW DOT AND ENABLE A/D HARDWARE
211
ODD FRAME ?
212
213
218
YES
NO
ENABLE A/D HARDWARE AND DISABLE SHOW DOT
OUTPUT DOT PIXEL LOCATION TO DOWN COUNTER
214
219
COMPUTE PREVIOUS FIRE PERIOD AND INCREMENT FIRE COUNT
INCREMENT FIRE COUNT
220
NO
FIRE COUNT = FIRE DOT NUMBER
215
YES
IS FIRE PERIOD TOO LONG OR TOO SHORT ?
YES
221
NO
ENABLE SHOW DOT AND CLEAR A/D HARDWARE
216
CALCULATE THE TIME FOR THE MAIN TO READ THE AMPLITUDE AND PIXEL
RETURN FROM FIRE INTERRUPT
217
START AGAIN

FIG-11

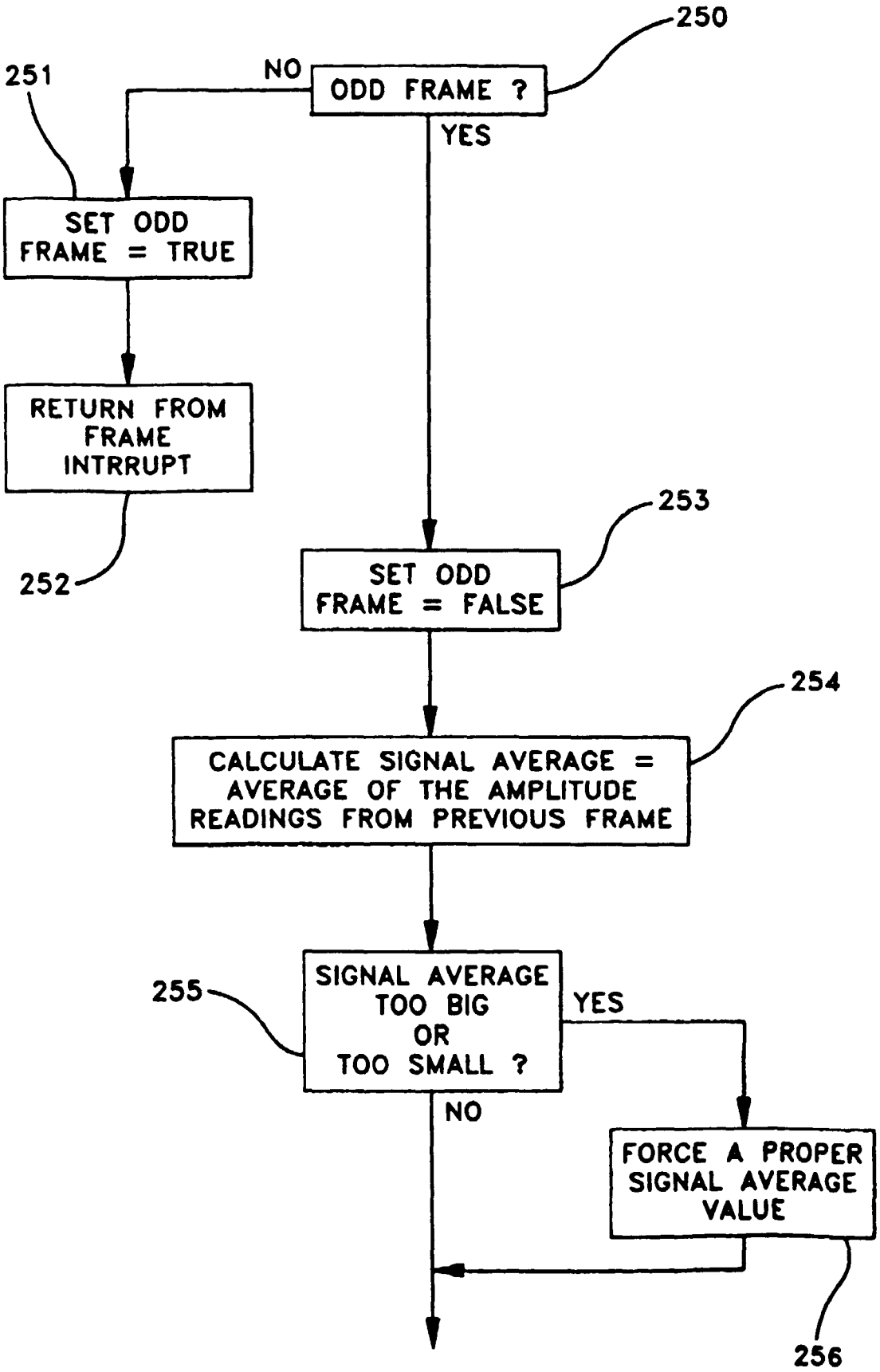
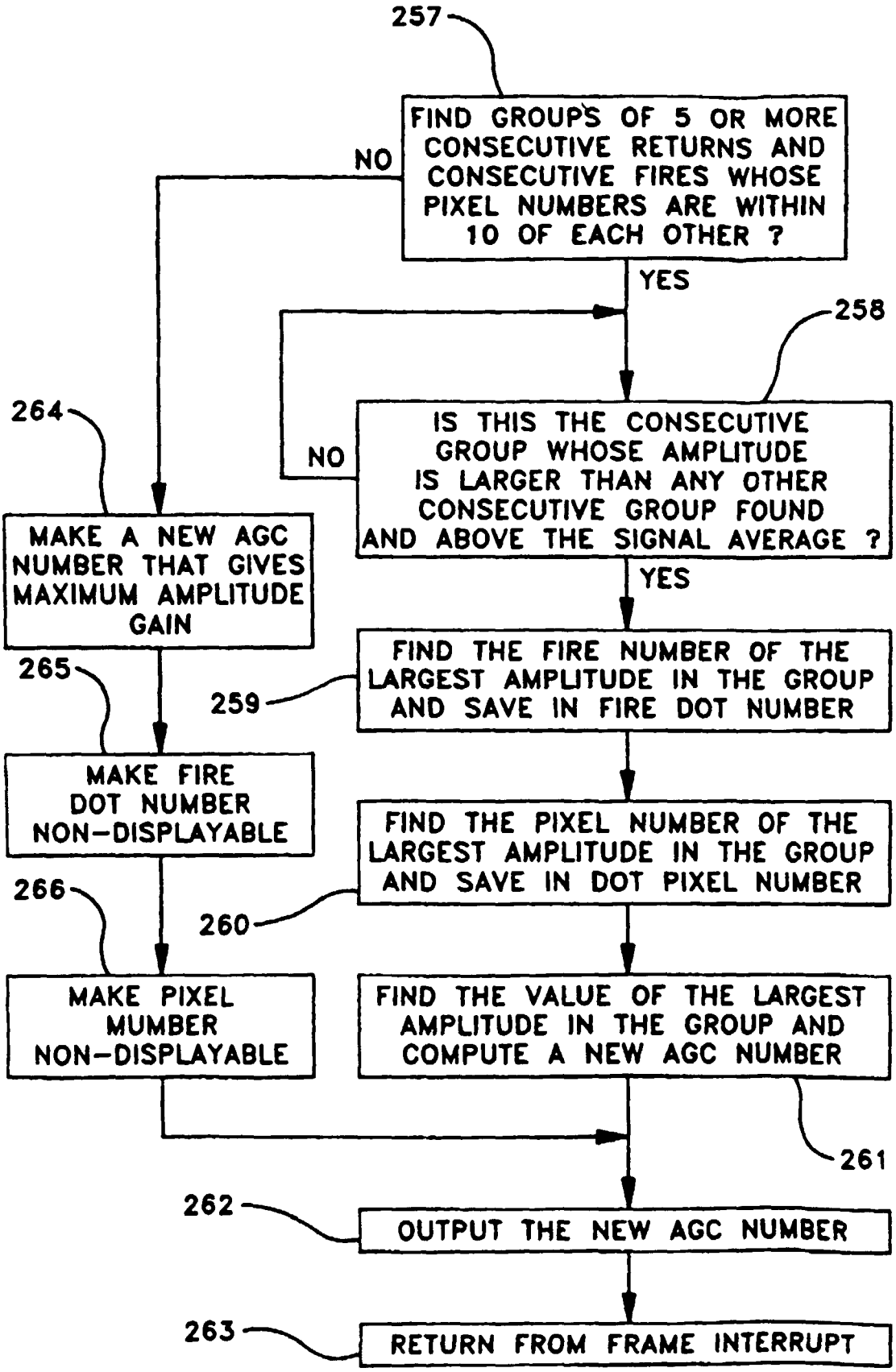

250
ODD FRAME ?
NO
YES
251
SET ODD FRAME = TRUE
RETURN FROM FRAME INTRRUPT
252
253
SET ODD FRAME = FALSE
254
CALCULATE SIGNAL AVERAGE = AVERAGE OF THE AMPLITUDE READINGS FROM PREVIOUS FRAME
255
SIGNAL AVERAGE TOO BIG OR TOO SMALL ?
YES
NO
FORCE A PROPER SIGNAL AVERAGE VALUE
256

FIG-12


257
FIND GROUPS OF 5 OR MORE CONSECUTIVE RETURNS AND CONSECUTIVE FIRES WHOSE PIXEL NUMBERS ARE WITHIN 10 OF EACH OTHER ?
NO
YES
258
IS THIS THE CONSECUTIVE GROUP WHOSE AMPLITUDE IS LARGER THAN ANY OTHER CONSECUTIVE GROUP FOUND AND ABOVE THE SIGNAL AVERAGE ?
NO
YES
264
MAKE A NEW AGC NUMBER THAT GIVES MAXIMUM AMPLITUDE GAIN
259
FIND THE FIRE NUMBER OF THE LARGEST AMPLITUDE IN THE GROUP AND SAVE IN FIRE DOT NUMBER
265
MAKE FIRE DOT NUMBER NON-DISPLAYABLE
260
FIND THE PIXEL NUMBER OF THE LARGEST AMPLITUDE IN THE GROUP AND SAVE IN DOT PIXEL NUMBER
266
MAKE PIXEL MUMBER NON-DISPLAYABLE
FIND THE VALUE OF THE LARGEST AMPLITUDE IN THE GROUP AND COMPUTE A NEW AGC NUMBER
261
262
OUTPUT THE NEW AGC NUMBER
263
RETURN FROM FRAME INTERRUPT